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Hywel Dda University Health Board

Evaluation Report

National Evaluation of the Institute of Clinical Science and Technology Respiratory Toolkit

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Funded by: Chief Executives across Wales

Who We Are

In 2021 the Tritech Institute was launched. We are a team based in a bespoke facility within Hywel Dda University Health Board comprising of industry-leading engineers, scientists and clinicians.

Our Institute

Here at the TriTech Institute, we support the development of healthcare solutions on a local, national, and global level offering designers and manufacturers a single point of access to the NHS through a collaborative and agile approach.

What We Offer

The team's advanced skills in clinical and research design are combined with technical engineering expertise to manage the whole innovative pathway from early unmet need, through to concept design, prototyping, clinical investigations, and real-world service evaluations.

Our Services

We provide specific services and solutions for clinical engineering, research and innovation and Value-Based healthcare, and can also support with grant writing and submission.

Executive Summary

Situation

The state of asthma and COPD care in Wales has been identified as generally poor. This is manifested by late diagnoses, a failure to provide many aspects of basic care and a failure to collect adequate data. For example, data from the 2017/18 Wales primary care clinical audit showed that 75% of adults and 80% of children with asthma had no evidence of a personalised action plan in the previous year. Furthermore, only 49% of adults, and 35% of children had their inhaler techniques checked in the previous year (Royal College of Physicians, 2020). A follow-up audit in 2020 showed no improvement in these outcomes (Royal College of Physicians, 2021), suggesting a different approach was needed to change outcomes for people with asthma and COPD in Wales. Additionally, it is important to note that due to a lack of routine data collection, demonstrating the benefit of any intervention is also harder. The Respiratory Health Implementation Group (RHIG) aimed to use digital innovation to address some of the issues with respiratory care and reduce variation in practice across Wales. Since 2015, RHIG has worked with the Institute of Clinical Science and Technology (ICST) to develop and deliver digital solutions in a range of different areas, including asthma, chronic obstructive pulmonary disease (COPD), COVID-19 and tracheostomy care. The ICST respiratory toolkit is a multi-app platform designed to support Asthma and COPD patients manage their conditions and to support healthcare professionals (HCP's) throughout Wales. In early 2024 the Chief Executives across Wales agreed to commission the Tritech Institute in Hywel dda University Health Board to perform a real-world evaluation of the platform, with the outcomes of this evaluation supporting decision making on future commissioning.

Description of the ICST Toolkit

The solution developed by ICST provides the infrastructure in which to disseminate policy and guidelines to its users (both health care professionals and individuals with asthma and/or COPD) and digital support tools to help people manage their condition across Wales. The toolkit is underpinned by a digital implementation framework, to facilitate the rapid system-wide dissemination of resources, and consists of three key elements:

1) Healthhub: A patient-facing component which consists of three 'Healthhub' applications, COPDhub, Asthmahub and Asthmahub for Parents. The Healthhub applications consist of a management plan, management tools such as a monthly checker to help individuals to monitor their condition, a decision support tool to help manage symptoms, and general education to help individuals to keep well and symptom-free.

2) All Wales ICST Platform: A HCP facing component which consists of a digital platform to offer HCPs a range of learning opportunities, tutorials and guidelines, aimed at improving and standardising respiratory care across Wales. Additionally, ICST disseminate hard copies of the All-Wales guidelines to HCPs, hold events and undertake Quality Improvement (QI) projects as part of the offering.

3) Commissioners Dashboard: A separate data dashboard for commissioners serves as a reporting mechanism, allowing commissioners and clinical leads to view data on the uptake and engagement of the toolkit within their locality. It also visualises measurable outcomes generated by the toolkit.

Evaluation Methodology

The ICST toolkit was evaluated through a mixed methods approach. Quantitative and qualitative data from multiple sources were used to evaluate the toolkit's impact on patient outcomes, behaviour change, and its effectiveness in helping people with asthma and COPD manage their conditions. Surveys were conducted with both patients and healthcare professionals (HCPs) to gather feedback on usability. Additionally, interviews with patients, HCPs, and commissioners were carried out to assess the broader value of the toolkit.

Findings

Uptake of the respiratory Toolkit: Uptake of the toolkit across Wales is underpinned by the development of an implementation science framework, which has been successfully utilised in the adoption of a national COVID-19 guideline (Jefferies et al., 2022), a national TB screening pathway for Ukrainian refugees (Barry et al., 2023) and a national tracheostomy toolkit (Twose et al., 2024),

This approach has seen the three patient-facing apps achieve widespread adoption across Wales, with at least one asthma or COPD patient using one of the apps in 100% of the main GP practices, with a median number of 34 app users in each practice, up to 285 in the highest adopting practice (mean of 47.2 users). Additionally, the staff-facing All Wales ICST Platform has seen an exceptional uptake amongst healthcare professionals (HCPs), with over 60% of all primary care nurses and GPs and over 40% of all consultants (>90% amongst respiratory) across Wales signed up to the platform.

Although the actual number of app users is low when compared to the total target population (5-6%), the national spread and excellent HCP uptake provide a good foundation to scale. Additionally, it must be recognised that the adoption and spread of new innovations takes considerable time; conventional wisdom suggests it takes around 17 years from medical innovation to adoption in the real-world (Morris, S., et al., 2011). Furthermore, uptake of patient-facing apps has experienced a linear increase since launch, despite uncertainties surrounding continued funding during this period, and uncertainty amongst HCPs e.g. one HCP responded 'told by my line manager funding would be stopping', when asked why they did not encourage their patients to use the apps. However, some potential issues were identified, such as the majority (>50%) of app users only used tools to check their condition once. Additionally, some evidence indicated that the uptake of COPDhub was lower in more deprived areas in Aneurin Bevan University Health Board. However, there were no major correlations between uptake and deprivation across the other six health boards. Similarly, uptake of the Asthmahub apps was found to be independent of deprivation.

Notably, high uptake of the All Wales Dashboard amongst primary care HCPs significantly predicts the number of patient users at any given GP practice, highlighting the importance of HCPs in driving patient adoption. About 65% of HCPs surveyed said they encouraged patients to use the apps, but it is unclear if this translates to increased awareness, as the most common reason respondents gave for not using the apps was that they had "never heard of it". Low overall uptake amongst patients may be symptomatic and needs to be addressed directly rather than being seen as an intrinsic issue with the intervention. With apps present in almost all GP practices, the challenge is to ensure HCPs are confident in the long-term support of the toolkit and are promoting the apps to service users. If the potential of the toolkit it is to be realised, it is important that it is fully supported at the national level.

Impact of the Toolkit on Patients: The patient engagement activities in this evaluation revealed a significant improvement in patients' ability to manage their conditions since downloading the app. Patient Recorded Outcome Measures (PROMs) from patients who used the app more than once demonstrated statistically significant improvements in good asthma control after as little as one month's use. Additionally, positive trends were observed in relation to reduced reliever inhaler use and good COPD control. Patients reported increased opportunities to

change their health behaviours and enhance their understanding and management of their conditions. Most participants expressed satisfaction with the app and would recommend it to others. User interviews conducted as part of the evaluation identified four key themes: 1) Empowering Patients to Take Charge, 2) Effortless Use, 3) Unlocking the Potential of Key Features, and 4) Personalising the Self-Management Tool.

Effect of the toolkit on patient outcomes: Direct reports from users suggested benefit in the form of improved asthma and COPD control after using the app. However, given the low level of use on a population level, it is hard to be confident of impact. Additionally, asthma and lung UK survey data do not suggest improvements in patient experience or care over the time course covered here. A limitation of the evaluation was the lack of direct evidence showing the app's effect on reducing hospital admissions or improving patient wellbeing, despite patient surveys indicating fewer healthcare system visits. This was primarily due to a lack of integration between ICST and NHS datasets. Generally, the level of uptake of the Healthhub apps by GP practice had some association with better outcomes, however, associations do not imply causation and could be confounded by other factors.

Effect of the toolkit on inhaler use: Currently, Wales is outperforming the other home nations in reducing high global warming potential (GWP) inhaler use. There has been no change in England, a deterioration in N Ireland and Scotland and only in Wales a significant switch to low GWP inhalers. This change towards dry powder inhalers (DPIs) and soft mist inhalers (SMIs) was found to correlate significantly with uptake of the Healthhub apps. Overall, the results suggest that the ICST toolkit has played a crucial role in supporting the switch to low GWP inhalers in Wales. The shift to DPI/SMI inhalers and changes in inhaler usage have positively impacted the environment. Practices with high adoption of the Healthhub apps have seen a significantly lower carbon footprint from prescribed inhalers. Wales is on course to meet the England 2030 target (50% of inhalers being low GWP) this year.

Impact on Health Care Professionals: Healthcare professionals (HCPs) were generally favourable towards the Healthhub apps, with most respondents believing the apps enhanced their consultations and helped patients manage their conditions more effectively. Interviews with primary care staff identified four key themes: 1) Standardising Clinical Practice, 2) Empowering Practitioners and Patients, 3) Accessible and User-Friendly Platform, and 4) Sustaining and Enhancing Impact. Similarly, interviews with secondary care healthcare professionals (HCPs) revealed four key themes: 1) Empowering Excellence Through Training, 2) Consistency That Builds Confidence, 3) Bridging Barriers Through Accessibility, and 4) Enhancing Integration for Holistic Care. In addition, it was identified that the Commissioners Dashboard should focus on displaying patient outcome measures.

Usability Analysis of the ICST Respiratory Toolkit: Although user opinion for the toolkit (both patients and HCPs) was generally positive, formal usability measures for the Healthhub apps have identified several issues. Usability analysis indicated that there is room for improvement, particularly in enhancing user engagement and emotional impact. To elevate the app's usability and emotional appeal, targeted improvements could focus on increasing engagement and providing support features that simplify the experience for new or less technical users.

In comparison, the usability analysis of the All-Wales ICST platform for HCPs indicates a generally positive user experience. The platform was rated as "good" to "excellent" in usability, with many participants finding it highly intuitive and engaging. This positive feedback suggests that the platform effectively meets the needs of HCPs, though some areas could benefit from targeted enhancements for new or less tech-savvy users. Overall, these findings provide a strong foundation for understanding user satisfaction with the platform, though future studies could benefit from task-based usability testing and more targeted industry benchmarks to address these limitations.

Value assessment of the ICST platform: The Healthhub apps have proven valuable in helping individuals with COPD and asthma manage their conditions more effectively. Importantly, respondents across all apps agreed or strongly agreed that the app has reduced their worry or anxiety about their condition. Survey results indicated an overall positive effect on health-related outcomes, including reductions in GP visits and ED admissions. Additionally, the majority of respondents reported finding their appointments with healthcare professionals more useful since using the app. Interviews provided further insight into how interactions with the apps could lead to improved outcomes.

The HCP survey indicated strong approval of the ICST respiratory toolkit among HCPs in Wales. Interviews reflected this value, with practitioners feeling empowered to deliver consistent, reliable care, ultimately leading to improved patient outcomes. A consistent theme throughout the interviews was the value provided by high-quality, centralised resources, with many HCPs expressing concern about the potential consequences of its absence. The toolkit is also part of a broader infrastructure created by ICST to deliver educational materials, training, and guidelines to staff across Wales, enabling the rapid delivery of evidence-based materials. This was evidenced during the coronavirus disease 2019 (COVID-19) pandemic, when guidelines delivered through the ICST platform and were adopted at scale. Additionally, Wales was the first country to create and disseminate a guideline on screening Ukrainians for TB through the ICST system, which demonstrates the ability of the system to be highly adaptable and successful in national level implementation.

Furthermore, it needs to be recognised that the respiratory toolkit is only one part of what ICST delivers; in addition to the respiratory toolkit, ICST has delivered a national tracheostomy programme which has seen thousands of HCPs complete tracheostomy training even though it is not mandated. Further guidelines developed and hosted by ICST include guidelines for headache management and a pathway for the management of abnormal liver function tests.

Conclusions

Overall satisfaction with both the patient-facing Healthhub apps and the staff-facing components of the toolkit was found to be high. Significant evidence highlights the toolkit's value in helping individuals with asthma and COPD manage their conditions more effectively, reducing the impact upon clinical services, and lowering anxiety and concerns surrounding their conditions. There was a strong desire among interviewed HCPs for the platform's continuation. Participants consistently recognised the value of the toolkit in providing high-quality, centralised resources and expressed concern about the potential consequences of its absence. The platform's guidelines and tools were seen as crucial in reducing variability in clinical practice across different settings and roles, ensuring consistent and high-quality care across Wales. Maintaining the platform's availability is considered essential for sustaining progress in respiratory care.

Significant evidence supports the toolkit's impact on switching from high GWP inhalers to low GWP inhalers. This reinforces the toolkit's value in supporting the green agenda and working towards the NHS Wales target of reducing the percentage of high GWP inhalers, and highlights a population behaviour change amongst HCPs, for which the toolkit has been a key factor in driving. Additionally, there is evidence suggesting that the Healthhub apps may have also influenced the number of ED or GP visits.

Overall, ICST has developed a platform with strong support from HCPs across Wales. The platform can quickly develop and disseminate new evidence-based guidance and has an established user base among individuals with COPD and asthma, who are benefiting from the apps as evidenced by improvements in various respiratory metrics. Although population-level adoption of the Healthhub apps across Wales amongst individuals with asthma and COPD remains relatively low, a strong foundation to scale has been developed, with an excellent spread across Wales and high uptake amongst HCPs. Additionally, ICST has received substantial recognition for the success of the toolkit nationally (UK and Wales-wide) through the receipt of numerous awards (Appendix 15). It should also be noted that all three apps were classified as 'good' during an independent review by ORCHA (Appendix 16). If the adoption of the Healthhub apps continues to increase across Wales, it is anticipated that this could lead to a significant positive impact on patient outcomes and reduce healthcare resource utilisation.

Based on this evaluation, several key recommendations are made:

Recommendation 1: Currently, only a small percentage (6%) of potential users in Wales are using the apps. While there is steady year-on-year uptake, strategies need to be implemented to increase this. System processes/incentives should be provided to ensure a rapid rollout of the ICST toolkit elements to ensure maximum impact. Efforts should focus on ensuring HCPs are confident in the long-term support of the toolkit and are engaged in promoting the apps to service users, as their engagement appears to drive patient interaction. Additionally, attention should be given to areas in Wales with slower uptake.

Recommendation 1.1: Some evidence indicates a lower uptake of the COPDhub app in deprived areas. To ensure equitable adoption across Wales, efforts should be made to promote the app in deprived regions, particularly in the Aneurin Bevan University Health Board, where the disparity was most pronounced.

Recommendation 1.2: Ensure system processes/incentives and support at a national level are in place to sustain engagement with the toolkit. Increasing user engagement and therefore impact is key to value for money.

Recommendation 2: Should the respiratory toolkit continue to be commissioned, the information provided to commissioners should shift to focus on patient outcomes, aligning with the principles of Value-Based healthcare.

Recommendation 3: Explore the potential for integrating the Healthhub apps with other healthcare Digital systems across Wales. Additionally, integrate the ICST datasets with NHS datasets where possible to ensure a fully implemented Value-Based approach to adoption.

Recommendation 4: Explore ways to enhance the usability, visual appeal and personalisation of the Healthhub apps, in ways that are aligned with the primary medical purpose of the apps.

Recommendation 5: Conduct app-specific usability testing to identify the challenges for lower-scoring user groups and prioritise the necessary refinements.

Recommendation 6: Enhance the onboarding processes for the Healthhub apps to ensure new users can easily discover and utilise key features like peak flow diaries, trend lines, and can easily identify their inhaler type and track their inhaler use effectively through the apps.

Recommendation 7: Evaluate the design elements of the Healthhub apps. For instance, assess and refine unclear question phrasing and consider adding a "Not Applicable" option to maintain user engagement.

Recommendation 8: Explore adding new features to Healthhub, such as enabling patients to customise notifications, set personal goals, or concentrate on specific health issues like stress-induced asthma or exacerbation triggers. Additional tools, such as prompts for managing exacerbations or environmental tracking (e.g., air quality), would be desirable to further enhance personalized care, however, the potential to personalise could be limited by medical device regulation.

Recommendation 9: It is vital that the All Wales guidelines continue to be maintained and are widely accessible for HCPs to ensure equitable and evidence-based respiratory care across Wales.

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Abbreviations

A&E
Accident and Emergency

ABUHB
Aneurin Bevan University Health Board

ATiC
Assistive Technologies Innovation Centre

AWTTC
All Wales Therapeutics and Toxicology Centre

BCUHB
Betsi Cadwaladr University Health Board

BCW
Behaviour Change Wheel

CAVUHB
Cardiff and Vale University Health Board

CLR
Critical Literature Review

COM-B
Capability Opportunity Motivation-Behaviour

CTMUHB
Cwm Taf Morgannwg University Health Board

DHCW
Digital Health and Care Wales

DHT
Digital Health Technologies

DPI
Dry Powder Inhaler

ED
Emergency Department

GP
General Practitioner

GWP
Global Warming Potential

HCP
Healthcare Professional

HDUHB
Hywel Dda University Health Board

ICST
The Institute of Clinical Science and Technology

IQR
Interquartile Range

MDI
Metered Dose Inhaler

MDR
Medical Device Regulation

NRAP
National Respiratory Audit Programme

NHS
National Health Service

PTHB
Powys Teaching Health Board

PREM
Patient Recorded Experience Measure

PROM
Patient Recorded Outcome Measure

R&D
Research and Development

RCP3Q
Royal College of Physicians 3 Questions

RHIG
Respiratory Health Implementation Group

SAMD
Software as a Medical Device

SBUHB
Swansea Bay University Health Board

SMI
Soft Mist Inhaler

SUS
System Usability Scale

TDF
Theoretical Domains Framework

UEQ
User Experience Questionnaire

UWTSD
University of Wales Trinity Saint David

WIMD
Welsh Index of Multiple Deprivation

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1. Situation

In April 2024, the Tritech Institute and Innovation team at Hywel Dda University Health Board (HDUHB) were commissioned by the Chief Executives across Wales to conduct a real-world evaluation of the Institute of Clinical Science & Technology (ICST) respiratory toolkit. This project, funded by the Chief Executives, aimed to assess the toolkit's real-world value for healthcare professionals (HCPs) and patients across Wales. The goal was to provide evidence for the Chief Executives to decide on the continued commissioning of the toolkit. This report presents the findings from the evaluation, covering the period from April 1, 2024, to December 31, 2024.

1.1 Why was the ICST Respiratory Toolkit Needed?

The ICST respiratory toolkit was developed as a response to the need to improve the basic level of care for asthma and COPD in Wales. Data from 2017/18 showed that 75% of adults and 80% of children with asthma had no evidence of a personalised action plan in the previous year. Furthermore, only 49% of adults had their inhaler techniques checked, and an even lower percentage of children (Royal College of Physicians, 2020). A follow-up audit in 2020 showed no improvement in these outcomes (Royal College of Physicians, 2021), suggesting a different approach was needed to change outcomes for people with asthma and COPD in Wales. Asthma and COPD are the two most prevalent lung conditions in Wales with an estimated 314,000 people currently receiving treatment for asthma (including 59,000 children) and 74,000 people diagnosed with COPD (Asthma and Lung UK, 2024). This costs the NHS in Wales £295 million in direct costs each year, representing 1.3% of the total NHS expenditure, with an estimated overall impact of £772 million on the Welsh economy (Asthma and Lung UK, 2023).

This need formed the basis for commissioning ICST to develop the Toolkit for Wales. The primary goal of the respiratory health delivery plan 2018-2020 was to reduce inappropriate variation and share best practices (Welsh Government, 2018). For example, NICE guidelines recommend offering all asthma patients a personalised action plan (NICE, 2021). Research indicates that individuals with asthma who have a self-management plan and receive regular community support use fewer healthcare resources and experience improved quality of life across all levels of asthma severity (Hodkinson, A., et al., 2020). This functionality is provided through the Asthmahub app. Additionally, national audit data from 2018 revealed that 25% of patients on COPD registers might not have COPD (Fisk, M., et al.). Consequently, significant efforts were made to deliver quality-assured spirometry training across Wales, facilitated through ICST infrastructure.

1.2 Aims of the ICST Respiratory Toolkit

Following commissioning, ICST were provided with a brief to develop an overarching digital solution to help manage COPD and Asthma patients across Wales. The mission statement of ICST is stated as:

"To create toolkits that enable individuals across large populations to have better agency, better empowerment and more confidence when they navigate their health. Our digital therapeutics cover some of the major chronic conditions, and have been proven to improve patient wellness, reduce the patient's need for unscheduled care and reduce expenditure of chronic diseases.

We empower patients to become expert patients and empower healthcare professionals to support their patients to stay well."

1.3 What is the ICST Respiratory Toolkit?

ICST developed the respiratory toolkit to provide an infrastructure for disseminating policies, guidelines, educational materials, and training to respiratory healthcare professionals and individuals with asthma and/or COPD. This toolkit includes digital support tools in the form of three 'Healthhub' apps. Commissioned by Welsh Government in 2015, the toolkit has been live since late 2019 and consists of three components:

1. **Healthhub:** A patient-facing component which consists of three 'Healthhub' applications, COPDhub, Asthmahub and Asthmahub for Parents. The Healthhub applications consist of a management plan, management tools such as a monthly checker to help individuals to monitor their condition, peak flow diaries, a decision support tool to help manage symptoms, and general education to help individuals to keep well and symptom-free. The apps were originally released in October 2019 and have since seen a combined almost 18,000 downloads across Wales (more information in Appendix 1 – 3).
2. **All Wales ICST Platform:** A HCP facing component which consists of a digital web-based platform. The All-Wales ICST Platform was developed to offer HCPs a range of learning opportunities, tutorials and guidelines, aimed at improving and standardising respiratory care across Wales. In addition to developing and hosting materials digitally via the platform, ICST disseminate hard copies of the All-Wales guidelines to HCPs, hold events and undertake QI projects as part of the offering.
3. **Commissioners Dashboard:** A separate data dashboard for commissioners consists of a digital web-based dashboard. The data dashboard is a reporting platform that enables commissioners and clinical leads to see data about the uptake and engagement of the toolkit within their locality, as well as visualising measurable outcomes generated by the toolkit. In addition to providing information via the online dashboard, ICST summarise information into scheduled reports which are disseminated to stakeholders via e-mail.

1.4 Stated Benefits of the ICST Respiratory Toolkit

ICST suggests the following via their website (ICST, 2024):

- 100% Coverage of GP practices that have patients using the toolkit.
- 90% of app users say the app helps them to manage their condition.
- 73% decrease in A&E visits by app users.
- 50% decrease in GP visits by app users.
- Several benefits to patients and providers (**see Table 1**)

Table 1. Claimed benefits of the ICST respiratory toolkit (ICST, 2024 (2)).

Benefits for Patients	Benefits for Providers
✓ Empowered patients stay well and reduce their need for unscheduled care	✓ Ability to reach large populations
✓ Support provided 365-days of the year	✓ When patients do visit the health system, their interactions are more efficient
✓ Patients feel in control of their condition and rely less on their rescue medications	✓ Less unscheduled care across prevalent chronic conditions
✓ Patients can engage in much more valuable healthcare consultations	✓ Financial savings

1.5 Purpose of the Evaluation

Despite the numerous successes and some positive feedback reported by ICST, the benefits of the toolkit have not been formally evaluated. Following a review of spending and the recommissioning of the service, the Chief Executives across Wales raised queries regarding the value, impact, and cost-effectiveness of the ICST respiratory toolkit, highlighting the need for an independent evaluation of its services. The Tritech Institute at Hywel Dda University Health Board was identified as a suitable organisation within NHS Wales to conduct this independent evaluation. The usability and user experience aspects of the evaluation were sub-commissioned to the Assistive Technologies Innovation Centre (ATiC) at the University of Wales Trinity Saint David (UWTSD), long-term collaborators of TriTech with expertise in evaluating medical technologies. The Chief Executives across Wales outlined two clear outcomes for this evaluation:

- A real-world evaluation would need to be commissioned to determine the value, or otherwise, of the toolkit; and
- The 'patient facing' aspects of the current contract with ICST are extended by up to 12 months to allow for the evaluation of the toolkit and, if appropriate, an open competition to appoint a provider of a digital respiratory toolkit.

The Chief Executives across Wales established the aim of the evaluation to address the following overarching question:

- **What value does the ICST respiratory toolkit bring to patients, healthcare professionals and the NHS in Wales?**

Considering, but not limited to the following components:

- Patient-facing Healthhub apps (COPDhub, Asthmahub, Asthmahub for Parents).
- The HCP-facing All Wales ICST Platform.
- The HCP-facing respiratory guidelines.
- The data dashboard for commissioners.

1.6 Scope of the Evaluation

To comprehensively evaluate the toolkit's value, the following elements, agreed upon by the Chief Executives, ICST, and the Tritech Institute, needed to be included in the evaluation:

- Literature Review
- Regulatory Review
- Uptake of the respiratory toolkit:
  - Is uptake affected by the geography of Wales?
  - Is uptake affected by deprivation?
- Impact of the toolkit on patients:
  - Patient Recorded Outcome Measures (PROMs)
  - Patient Recorded Experience Measures (PREMs)
- Effect of the toolkit on patient outcomes.
  - ED attendances.
  - Hospital admissions.
  - Outpatient appointments.
  - Primary Care Contacts (Scheduled and Unscheduled).
- Effect of the toolkit on inhaler use.
  - Behaviour change impact.
  - Corresponding environmental impact of changing inhaler habits.
- Impact of the toolkit on HCPs across Wales
  - Does the toolkit help HCPs to provide better care across Wales?
- Usability of the toolkit.
- Value-Based analysis:
  - What is the overall value of the toolkit?

2.0 Methodology

A mixed-methods approach was utilised to meet the aim of the evaluation via the objectives and outcomes set out below.

2.1 Literature Review

To assess the current evidence on the effectiveness of digital tools in promoting behaviour change and in helping individuals with COPD and asthma to manage their condition, a critical literature review was carried out. The review investigated whether digital applications can be successful in helping individuals with asthma and COPD to manage their condition, if apps are effective at encouraging behavioural change, and if this is reflected through an impact on patient outcomes.

- **Question 1:** How Effective is digital health technology in managing chronic obstructive pulmonary disease (COPD) from a patient and service perspective.
- **Question 2:** How Effective are Patient-facing Applications in the Management of Individuals with Asthma and Healthcare.

2.2 Regulatory Review

Regulatory information relating to software as a medical device (SAMD) and declaration of conformity were requested from ICST. Intended purpose of the patient-facing apps were investigated to ensure compliance with medical device regulations (MDR, 2002) (Medicines & Healthcare Products Regulatory Agency, 2024).

2.3 Uptake of the Respiratory Toolkit Data

The number of active users for the Healthhub apps was requested from ICST at a GP level. The relative deprivation of each area was quantified using the Welsh Index of Multiple Deprivation (WIMD) tool (Welsh Government, 2019). GPS co-ordinates were recorded for each of the GP practices utilising Google Maps to assess the uptake of the patient-facing applications relative to the geography of Wales. GPS co-ordinates and deprivation scores were correlated with the uptake in each GP practice, to determine equality of uptake across Wales in terms of geography and deprivation level. The relative uptake in each health board and cluster was also analysed to determine if there were significant differences in uptake related to geography.

Data on the number of HCPs using the All-Wales ICST Platform were requested from ICST at a GP locality level. Uptake of the platform was assessed at each health board and at a GP cluster level to determine equality of uptake across Wales. Regression analysis was carried out between the platform uptake and app uptake to investigate if the HCP uptake predicts app uptake amongst patients.

2.4 Impact of the Toolkit on Patients

2.4.1 Patient Reported Experience Measures (PREMs)

2.4.1.1 ICST Healthhub Survey 2023

In addition to the independent survey, raw data from a historic Healthhub survey developed and undertaken by ICST in 2023 was requested (Appendix 4). The survey was created to assess the impact of the apps on users in terms of wellness, and outcomes such as GP visits and hospital admissions. The survey was designed following the process outlined by Kasunic, M. (2005). To increase participation, the survey was designed to be short, with questions that were not compulsory. Additionally, attempts were made to mitigate biases, based on Choi, B. et al. (2005).

This survey was sent electronically to around 10,000 active users of all three Healthhub apps for completion during the week of November 14th 2023.

2.4.1.2 TriTech Institute / ATiC Healthhub Survey 2024

An independent survey was generated, which aimed to determine if the applications were useful for helping individuals with COPD and asthma to manage their condition, as well as the perceived impact of the toolkit on patient outcomes. The independent survey was also designed to assess the usability of the patient-facing applications, and to assess the potential behaviour change aspect of the applications, such as changes in inhaler use or management habits (Appendix 5). Both English and Welsh versions of the survey were available for respondents to complete.

The survey was distributed to app users through a poster featuring a QR code, which linked directly to the patient survey to facilitate easy responses (see Appendix 6 and Appendix 7). All GP practices in Wales were invited to take part in the evaluation (n = 368). Those that accepted were sent an electronic and hard copy of the poster to display in their waiting area. Additionally, the survey links and QR codes were shared to HCP networks across Wales encouraging HCPs to share the survey with their asthma and COPD patients. A link to the survey was also sent to Healthhub app users via the apps, utilising the ICST digital infrastructure.

The independent survey was created to assess patient experience of using the applications as well as usability and behaviour change that could be attributed to application use.

As part of this survey ATiC employed two widely recognised validated tools: the System Usability Scale (SUS) and the User Experience Questionnaire (UEQ). This was used to understand the ICST toolkits usability. See section 2.8 for more details.

2.4.1.2.1 Rationale for use of COM-B to inform evaluation questions

The COM-B model stands for Capability Opportunity Motivation-Behaviour. It now forms the first element of the wider Behaviour Change Wheel (Michie, S., et al., 2011) and helps policy makers understand behaviour requiring change in the context within which it occurs. The central tenet of the model is that in order for any behaviour to occur then an individual must have the capability to do it (have the knowledge and physical skills etc); the opportunity to do it (must have a conducive physical and social environment including being accessible, affordable, and socially acceptable); and have a strong motivation to engage in the relevant behaviour. When trying to change behaviour (in this context, increasing appropriate self-management behaviours), increasing one or more of these factors may also result in changes in the other factors (e.g., through increasing motivation, people may be more likely to engage with the App and therefore increase their psychological capability to understand how to self-manage their behaviours.

The COM-B model has been used extensively to inform the field of self-management apps including for respiratory conditions and in understanding aspects of self-management and adherence (Arden M.A., et al., 2021. Zhu, L., et al., 2023)

For the purposes of the ICST evaluation the COM-B model guidance and exemplars were used to initially develop fifteen items to capture relevant COM-B constructs which were then reduced to six final items following feedback and piloting in order to reduce participant burden. These are indicated in the final column in Table 1 below. Respondents were asked to rate each item on a 5-point scale, ranging from “strongly disagree” to “strongly agree.

2.4.1.2.2 Healthhub 2024 survey: Mapping across the context:

Table 1 outlines the mapping process for the evaluation of the patient group. The first column includes specific areas of “behavioural diagnosis” that can be used in a self-evaluation format to identify the barriers and facilitators to engagement with the App/Self-management behaviours.

Table 2. COM-B Behavioural diagnosis form mapped to theoretical areas of behaviour change and related evaluation questions.

In order for behaviour change to occur, the individual, group or organisation would need to:			
Behaviour Change Wheel (BCW) constructs and how assessed:	**Mapped to Respiratory App**	**Theoretical Domains Framework (TDF)**	**Final Questions included in ICST toolkit evaluation**
Capability			
Know more about why it is important	Have a better understanding of why self-management of your respiratory condition is important	Knowledge: Procedural knowledge	Using the App has helped me understand more about why it is important to manage my condition
Know more about how to do it	Understand the processes and procedures involved in self-management	Skills: Competence	The App has helped me understand how to manage my condition more effectively
Overcome mental obstacles	Manage own stress and negative feelings/ Learn how to manage the cognitive and emotional impact of engaging with self-management behaviours	Behavioural regulation: e.g. self-monitoring, action planning Beliefs about capabilities e.g. self-efficacy, empowerment, professional confidence	Using the App has reduced my level of worry and anxiety about my condition
Opportunity			
Have more triggers to prompt me	Have more reminders at strategic times of importance of self-management	Environmental context and resources	The App provides easy access to information that helps me self-manage my respiratory condition
Motivation			
Feel that you want to do it enough	Feel more of a sense of satisfaction from using the App	Intentions Stages of change Social/professional role and identity	I am more motivated to manage my condition since using the App
Develop better plans for doing it	Have clearer and better developed plans for how to self-manage their condition	Goals e.g., Goal setting Action planning Implementation intentions Beliefs about capabilities Skills	The App has empowered me to take control of my respiratory condition

2.4.2 Patient Reported Outcome Measures (PROMs)

In addition to the surveys carried out on the Healthhub apps, raw data from historic PROM surveys were requested from ICST where available. This included:

- Asthma checker monthly questionnaire (Appendix 8).
  - A monthly questionnaire, forwarded to users of the Asthmahub app, asks users 10 questions related to how well they feel they are managing their condition. A 'tick' for all 10 questions indicates a 'good' result.
- COPD checker monthly questionnaire (Appendix 9).
  - A monthly questionnaire, forwarded to users of the COPDhub app, asks users 12 questions related to how well they feel they are managing their condition. A 'tick' for all 12 questions and an additional tick for completing the COPD checker indicates a 'good' result.
- Royal college of physicians three questions (RCP3Q) (Appendix 8, question 10: RCP1, RCP2 and RCP3).
  - A validated PROM for monitoring asthma control (Pinnock et al., 2012). Included as part of the Asthma checker questionnaire on a monthly basis.

2.4.3 Patient Feedback

2.4.3.1 Patient Interviews

Patients who completed the survey had the option to provide their contact details for follow-up interviews. These semi-structured interviews allowed users to offer additional qualitative feedback on their experiences with the Healthhub apps (see Appendix 10).

2.5 Effect of the toolkit on patient outcomes

2.5.1 Secondary Care Outcomes

Patient secondary care outcomes were provided by Digital Health and Care Wales (DHCW). This included:

- ED attendances due to asthma and COPD.
- Hospital admissions due to asthma and COPD.
- Respiratory outpatient appointments related to asthma and COPD.

Outcome data was provided from February 2020 to April 2024. All patient outcomes were provided at the GP level.

Correlations between the outcome measures (ED attendances, hospital admissions, respiratory outpatient appointments and primary care contacts) and the uptake of the patient-facing apps at each GP practice were investigated. Additionally, the highest and lowest adopting practices of the health hub apps were compared to determine if there was a relationship between uptake and outcomes.

2.5.2 Primary Care Outcomes

Primary care outcomes were requested from all Welsh GP practices (n = 368). A datasheet and search guide were provided for the practices to complete (Appendix 11). Outcomes requested included scheduled and unscheduled appointments related to asthma and COPD.

Additionally, raw data of patient-reported GP attendances through the Asthmahub app were supplied by ICST containing all the monthly reports from January 2022 to May 2024. The first twelve months GP attendances were established as the sum of the GP attendances recorded in the twelve months from first app use. The follow up GP attendances were established as the sum of the GP attendances recorded in the twelve-month period starting 12 months after the first app use. Only app users who had interacted with the app at least 18 months after first use were included.

2.5.3 National Audits and survey

In addition to the bespoke and evaluation specific survey used in this piece of work we will also report on any specific national audits and surveys. These will be used to provide an overall understanding on COPD and Asthma care in the UK and Wales and will be used to compare against the findings from this evaluation. Two specific national pieces of work that will be reported on are: 1) Asthma and Lung UK Annual Survey and the 2) National Respiratory Audit Programme (NRAP).

2.6 Effect of the toolkit on inhaler use

2.6.1 Medication (Inhaler) Data

Inhaler data were obtained via the Server for Prescribing Information Reporting and Analysis (SPIRA) system, at the practice level. To determine any effect of the app on behaviour change with regards to inhaler usage, uptake level of the app in different GP practices was compared to changes in inhaler use across Wales.

Correlation analysis was carried out to determine the relationship between uptake and inhaler use. Additionally, differences in uptake were explored between the highest and lowest adopting practices of the Healthhub apps.

2.6.2 Environmental Effect

The environmental effect of inhaler switching was investigated through the literature. A carbon footprint analysis was carried out using data from SPIRA to determine the potential environmental impact of the Health Hub apps as a potential catalyst for switching to low global warming potential (GWP) inhalers.

2.7 Impact of the toolkit on HCPs across Wales

2.7.1 Health Care Professional Survey

An HCP survey was created using the same principles as the patient survey. The independent survey was created to assess staff experience of using the dashboard as well as to gather feedback on the perceived value of the various elements of the toolkit (Appendix 12). Both English and Welsh versions of the survey were available for respondents to complete.

The HCP survey was distributed to HCPs across Wales via professional networks such as the Welsh Thoracic Society mailing list and the ICST HCP mailing list.

2.7.2 Health Care Professional Interviews

Upon completing the survey, HCPs had the option to provide their contact details for follow-up interviews. These semi-structured interviews allowed users to offer additional qualitative feedback on their experiences with the various elements of the respiratory toolkit (see Appendix 13).

2.7.3 Commissioners Evaluation

ICST provides data and reports to commissioners, enabling them to view information on the uptake and engagement of the platform in their locality, as well as outcomes related to the toolkit in their area.

Reports are provided to commissioners on an ad-hoc basis, with more frequent updates during the early implementation phase of the toolkit, typically every two weeks, focusing on the uptake and engagement of the program. Once the program or toolkit is established in the locality, reporting becomes less frequent and shifts to emphasize the impact of the intervention on patient outcomes.

Commissioners were identified through the ICST mailing list and contacted to take part in semi-structured interviews. This included national clinical leads and chief executives.

Semi-structured interviews were conducted with commissioners to assess the value of the information provided by ICST, determine the usefulness of the reporting, and identify any additional information that could help guide their decisions (see Appendix 14).

2.8 Qualitative Data Analysis

A Reflexive Thematic Analysis (RTA) was conducted on Patient, Primary, and Secondary Care Data, according to Braun & Clarke's (2021) steps: familiarising myself with the data, coding it concisely to align with evaluation objectives of 1) Experience and Usage 2) Impact on Practice and Outcomes 3) Usability and Barriers, and 4) Effectiveness and Recommendations. Initial coding is followed by organizing codes into themes that reflect shared and unique experiences. Adopting a contextualist epistemology to balance participants' subjective views with the practical realities of tool use, and a relativist ontology to capture how individual contexts shape their perspectives. This approach ensures a nuanced and reflective analysis of the ICST tools' impact.

2.9 Usability Analysis of the Healthhub Apps

Usability analysis was first carried out using the aggregated survey data for all three of the Healthhub apps (COPDhub, Asthmahub for Parents, and Asthmahub). This initial analysis offers a general overview of the overall user experience and usability across the entire Healthhub Apps.

Subsequently, the data was segmented and analysed based on the specific app used by participants. This segmented analysis evaluates the individual performance of each app (COPDhub, Asthmahub for Parents, and Asthmahub) to highlight variations in user experience and usability across different contexts and user groups.

2.9.1 Usability/ User Experience

ATiC employed two widely recognised validated tools: the System Usability Scale (SUS) and the User Experience Questionnaire (UEQ).

The SUS consists of 10 statements rated on a 5-point scale, ranging from "strongly disagree" to "strongly agree." It provides an overall score for the app's usability, where scores above 68 are generally considered "above average." The SUS focuses on ease of use, effectiveness, and efficiency, making it ideal for assessing whether users can navigate the app/s intuitively and complete tasks without difficulty. The tool is widely used across industries and has been proven to offer reliable, valid results for measuring usability. It produces a single score between 0 and 100, offering a quick snapshot of how well users interact with the app/s.

The UEQ goes further by assessing six key dimensions of user experience: attractiveness, perspicuity (clarity), efficiency, dependability, stimulation (engagement), and novelty. Each dimension is rated using a 7-point semantic differential scale (e.g., from "annoying" to "enjoyable"). This approach captures not only the practical aspects of using the app but also how engaging and satisfying it is for users. A higher score in these categories indicates a more positive user experience. Research has shown the UEQ to be a reliable and valid method for evaluating the emotional and cognitive impact of software. The results from the UEQ provide detailed insights into both the functional and emotional aspects of the app, allowing developers to refine the user experience.

In this study, the short version of the UEQ was used to reduce the length of the survey while still collecting valuable input. The UEQ short version focuses on key aspects of user experience, such as attractiveness, perspicuity, efficiency, and dependability. Despite being a more concise version, it retains the ability to provide meaningful insights, making it an efficient tool for gathering feedback without overwhelming participants.

By combining the SUS for usability and the UEQ for a comprehensive view of user experience, areas where the "Health Hub" apps excels and where improvements might be needed can be identified, ensuring the apps meet both practical and emotional needs of users managing respiratory conditions (Brooke, J., 1996).

2.10 Value-Based Analysis

Value was determined through assessing the impact of the ICST toolkit components on both patients and healthcare professionals. This included the impact of the patient-facing applications on the ability of patients to manage their condition and the associated changes in ED attendances, hospital admissions and primary care appointments.

Other non-tangible value was identified through qualitative interviews with health care professionals and patients. Thematic analysis was carried out to identify key themes related to the various components of the toolkit. A major focus of the HCP interviews was to identify the value of the All-Wales ICST platform in providing health care professionals with the guidance to provide high-quality respiratory

care. Furthermore, the value of the toolkit manifested by the effect on patient outcomes was a key determinant of value. Outcomes were assessed both through PROMs and through analysis of key clinical outcomes such as hospital admissions and primary care contacts.

2.11 Data analysis

Statistics were carried out using IBM SPSS version 29. Data normality were assessed via Shapiro-Wilk test and Q-Q plots. Normally distributed data are presented as mean ± standard deviation, and non-normally distributed data are presented as median (IQR). Differences between independent normally distributed groups were assessed using Students t-test, and differences between independent non-normally distributed groups were assessed using Mann-Whitney test. Differences between paired normally distributed groups were assessed using paired t-test, and differences between paired non-normally distributed groups were assessed using Wilcoxon signed-rank test.

Repeated measures ANOVA with Bonferroni correction was used to make multiple comparisons. Correlations were assessed using the Pearson correlation coefficient.

3 Findings

3.1 Literature Reviews

Two literature reviews were carried out, one assessing the effectiveness of digital applications for the management of COPD (Appendix 17), and one assessing the effectiveness of digital applications for the management of asthma (Appendix 18). The literature reviews identified numerous pieces of evidence supporting the potential importance of digital health technologies (DHT) in the management of respiratory conditions. The evidence suggests that Digital Health Technologies (DHT) can play a crucial role in helping individuals self-manage their conditions. Additionally, it highlights the availability of numerous digital applications. The literature reviews are summarised below.

3.1.1 Literature Review 1: Effectiveness of digital health technology in managing chronic obstructive pulmonary disease (COPD): A patient and service perspective

Aim
The critical review of the literature set out to determine if digital health technologies (DHT) can positively impact healthcare services for COPD. The was undertaken by exploring the impact of these devices on patient and service outcomes and finally by looking at cost-effectiveness.

Methodology
This review used a native approach to a Critical Literature Review (CLR) to answer the research question. A database search using PubMed, SCOPUS and Cochrane CENTRAL was used to find relevant randomised control trials. Of the 302 articles found in the search, 12 were studied in this CLR.

Results
This CLR found mixed evidence regarding the effectiveness of digital health technologies. Importantly, despite the mixed results, there was no indication that DHT was harmful or negatively impacted the current standard of COPD care.

Conclusion
Digital Health Technologies (DHT) have the potential to play a crucial role in future health and care services. However, the mixed results indicate that further research and development are needed. Additionally, healthcare services must evolve to effectively integrate these new tools into their offerings.

3.1.2 Literature Review 2: The Effectiveness of Patient-facing Applications in the Management of Individuals with Asthma and Healthcare: A literature Review

Aim
This review aims to explore the effectiveness of managing individuals with bronchial asthma in healthcare. It critically examines how the use of apps impacts clinical, economic, and environmental outcomes for patients and healthcare systems, and ultimately assesses how well these innovations can be integrated into existing workflows.

Methodology
This review examines the effectiveness of apps in the management of patients with bronchial asthma in healthcare from 2010 to current. By doing so, it reviews relevant scholarly articles with the focus of assessing currently available apps for asthma self-management, potential benefits, and effectiveness in clinical practice. The work also delves into identifying gaps and procedures that affect the use of apps in healthcare. Ultimately, the research aims to recommend solutions for integrating these apps into healthcare systems.

Results
This CLR found mixed evidence in support of the use of digital applications for asthma management. Although there is some evidence to support the effectiveness of digital applications in helping individuals with asthma to manage their condition (Ramsey, R. R., et al., 2019, Khushal, R. J., et al., 2020, Poowuttikul, P., et al., 2020), there is a lack of conclusive data to determine the effectiveness and efficacy of these applications in the self-management of asthma (Himes, B. E., et al., 2019). Few studies have been carried out assessing the cost-effectiveness of using mobile applications for the management of asthma, however, a study by Van De Hei et al. carried out in 2022 demonstrated that apps can be cost saving in the self-management of asthma, although there was no significant change in QALY (Van De Hei, S. J., et al., 2022).

Conclusion
The support for applications and self-management holds great promise. Systematic reviews on interventions for chronic disease management have shown particularly promising results in improving self-management and health outcomes (Lee, D. L., et al., 2023; Tinschert, P., et al., 2017). Positive strategies such as use of automated text reminders, regular and precise monitoring of symptoms (sometimes in real time) and shared decision making are associated with patients increased knowledge and better self-management (Lee, D. L., et al. 2023).

3.2 Regulatory Review

3.2.1 Software as a Medical Device

As part of the evaluation, the current regulatory status of the ICST Toolkit was assessed. It was found that the three patient facing applications that make up the ICST Toolkit: COPDhub, Asthmahub and Asthmahub for Parents are registered under the MHRA as class 1 medical devices. This can be seen below:

Description of 'Devices': COPDhub - Asthmahub - Asthmahub for Parents

A suite of mobile applications downloadable from Apple and Android App stores. Its purpose is to support patients to self-manage their conditions with personal information and generic information. The key features include generic education via videos delivered by clinicians, it is a repository for personal clinical information such as medications prescribed and key 'normal' test values. The app also supports self-management through calendars, diary reminders and a generic symptom support manager.

Medical device Regulations Classification Description: Description of a Class I device

ICST Toolkit Registration:
MHRA Reference Number: 9213
GMDN Code: 58884
PARD (mhra.gov.uk)

Class I medical Devices are low risk, non-invasive, everyday devices or appliances. The manufacturer is required to issue the EU declaration of conformity and to draw up the technical documentation for such devices. The declaration of conformity for the ICST toolkit can be seen below:

ICST Class I device declaration of Conformity
This declaration of conformity is issued under the sole responsibility of The Institute of Clinical Science and Technology. We hereby declare that the medical devices specified above meet the provision of the Regulation (EU) MDR 2017/745 for medical devices. All supporting documentation is retained at the premises of the manufacturer.

3.2.2 Implementation of NICE Guidelines

As part of the offering, ICST work with various experts from NHS Wales to develop the All Wales Respiratory Pathways and Guidelines, which are designed to help HCPs in Wales to follow best practice in the diagnosis and management of respiratory conditions. The pathways and guidelines include guidelines for the diagnosis and management of asthma, COPD and bronchiolitis, and are available for HCPs to access on the All-Wales ICST Platform.

The guidelines were developed and maintained by the Respiratory Health Implementation Group, who are guided by the Quality statement for respiratory disease (Welsh Government, 2022).

Recently, a new asthma guideline was developed collaboratively by NICE, BTS, and the Scottish Intercollegiate Guidelines Network (SIGN) (National Institute for Health and Care Excellence, 2024). This guideline includes an asthma pathway with recommendations for the diagnosis, monitoring, and management of asthma in adults, young people, and children.

The All-Wales asthma guidelines are well-aligned with the NICE recommendations, incorporating several changes such as SABA-free pathways, the routine use of asthma action plans, and regular (at least annual) asthma reviews. Additionally, the All-Wales asthma guidelines will be reviewed upon the publication of the 2024 NICE guidelines (All Wales Medicines Strategy Group, Respiratory Health Implementation Group, 2024)

It is vital that the guidelines continue to be maintained and are widely accessible for HCPs to ensure equitable and evidence-based respiratory care across Wales.

3.3 Uptake of the ICST Toolkit

3.3.1 Patient-facing Applications: Healthhub

Uptake of the three patient-facing applications were assessed via data provided by ICST. A steady increase of around 6,000 new users per annum in uptake of all three applications was observed across Wales from October 2022 to June 2024. The latest data from June 2024 indicated 2,292 users for Asthmahub for parents, 4,388 users for COPDhub and 11,892 users for Asthmahub (Figure 1). This equates to around 6% of individuals with a COPD diagnosis in Wales, 5% of individuals with an asthma diagnosis, and 4% of parents of children with an asthma diagnosis (Asthma & Lung UK, 2024).

Figure 1. Uptake of the Asthmahub for parents, COPDhub and Asthmahub applications across Wales (October 2022 to June 2024).

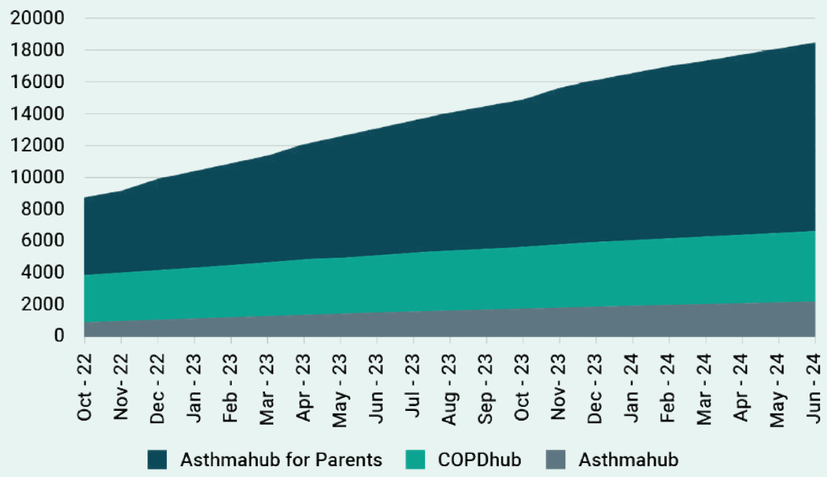


Table 3. Coverage of Healthhub apps across Wales. Data shows the total number of main GP practices in each health board and in Wales as a whole, the number of those practices that has at least one user for each Healthhub app, and the median number of users for each GP practice in the region.

Region	Number of main practices	App	Number of main practices in region with at least one user (n, %)	Median number of users (n, IQR, %)
ABHUB	72	COPDhub	71 (99%)	9 (5, 12) (5.0%)
		Asthmahub	72 (100%)	18.5 (10, 25.5) (4.8%)
		Asthmahub for parents	65 (90%)	3 (2, 6) (3.8%)
		All Apps	72 (100%)	30 (18.75, 42.75) (4.7%)
BCUHB	99	COPDhub	98 (99%)	7 (5, 12) (5.6%)
		Asthmahub	98 (99%)	10 (5, 20.5) (4.2%)
		Asthmahub for parents	71 (72%)	2 (0, 4) (3.0%)
		All Apps	99 (100%)	19 (11.5, 43) (4.4%)
CTMUHB	50	COPDhub	47 (94%)	4.5 (3, 12) (3.4%)
		Asthmahub	50 (100%)	18 (6.25, 30) (4.9%)
		Asthmahub for Parents	49 (98%)	7 (3, 8.75) (4.9%)
		All Apps	50 (100%)	32.5 (14.25, 47.75) (4.5%)
CAVUHB	61	COPDhub	61 (100%)	14 (8, 18) (9.7%)
		Asthmahub	61 (100%)	43 (21, 67) (10.6%)
		Asthmahub for Parents	60 (98%)	8 (4, 15) (9.3%)
		All Apps	61 (100%)	64 (38, 96) (10.2%)
HDUHB	47	COPDhub	46 (98%)	11 (5, 16) (5.6%)
		Asthmahub	47 (100%)	44 (16, 58) (8.4%)
		Asthmahub for Parents	46 (98%)	8 (5, 15.5) (8.4%)
		All Apps	47 (100%)	60 (30, 88.5) (7.7%)
PTHB	16	COPDhub	16 (100%)	19.5 (11.25, 22) (8.3%)
		Asthmahub	16 (100%)	30.5 (16.75, 42.25) (5.9%)
		Asthmahub for Parents	15 (94%)	3 (1.75, 5.25) (3.1%)
		All Apps	16 (100%)	45.5 (38.5, 68.25) (6.1%)
SBUHB	47	COPDhub	47 (100%)	10 (5, 13.5) (5.7%)
		Asthmahub	47 (100%)	19 (11, 35.5) (5.5%)
		Asthmahub for Parents	40 (85%)	3 (1.5, 5) (3.4%)
		All Apps	47 (100%)	30 (19.5, 55) (5.2%)
Wales	392	COPDhub	386 (98%)	9 (5, 15) (5.9%)
		Asthmahub	391 (99%)	19.5 (9, 42) (4.7%)
		Asthmahub for Parents	346 (88%)	4 (2, 8) (3.9%)
		All Apps	392 (100%)	34 (17, 64) (4.8%)

3.3.2 Uptake by Geography Across Wales

Uptake of the three patient-facing apps was found to be well established, with at least one asthma or COPD patient using one of the apps at 100% of the main GP practices across Wales. A summary of the uptake of the three apps across Wales is shown in Table 3 below. Across Wales a median of 34 (17, 64) patients with asthma or COPD per GP practice was found to be using either COPDhub, Asthmahub or Asthmahub for parents (mean 47.2 ± 42.6). The highest uptake of the Healthhub apps in terms of absolute number of users was found in Cardiff and Vale UHB, with each GP practice having a median number of users of 64 (38, 96) across all three Healthhub apps.

A possible rationale for the differences in uptake is that certain health boards in Wales serve larger populations, with larger patient populations at their GP practices. To account for the difference in local population, the uptake analysis was carried out using percentage of total individuals with COPD or asthma in each locality (see Figure 2). Despite the corrected analysis uptake of the three apps remained the highest in Cardiff and Vale University Health Board with around 9.2-10.6% uptake amongst individuals with asthma and COPD for all three apps. The lowest uptake was found in Betsi Cadwaladr University Health Board, with an overall uptake of around 4.4%.

When exploring the relationship between uptake and geography across Wales a significant but weak correlation was observed between percentage of individuals with asthma (Asthmahub & Asthmahub for Parents) using the app and geographical location (determined by GP practice location). The relationship indicates an increase in relative uptake of the apps in the South and West of Wales compared to other parts of Wales. No significant correlations were observed between COPDhub uptake and geographical location across Wales.

Figure 2. Uptake of Asthmahub, Asthmahub for Parents and COPDhub apps as a percentage of the total number of Asthma/COPD patients in each health board (GP Contract, 2019, Asthma & Lung UK, 2024).

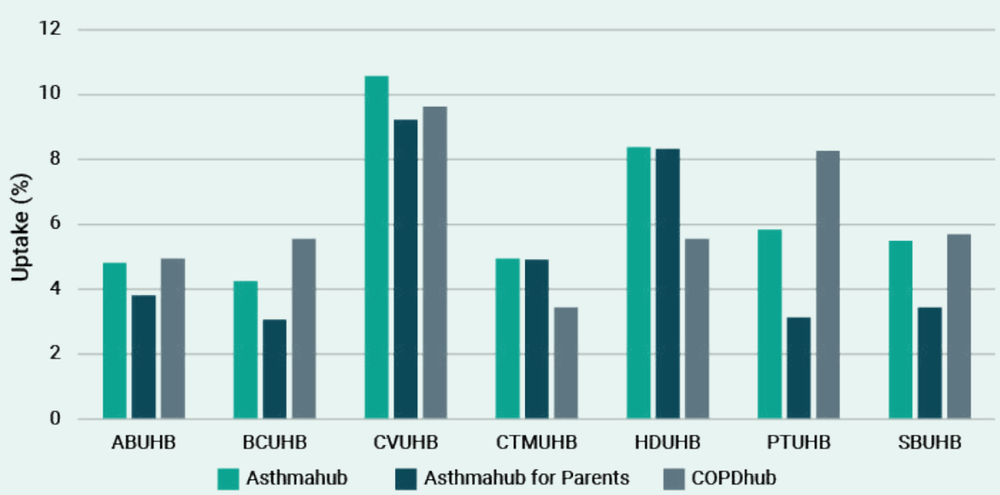


Table 4. Correlation analysis between uptake of Healthhub apps and location in Wales. Data presented as Pearson correlation of latitude/longitude co-ordinates of a GP practice and the number of users at that practice/% of individuals with asthma or COPD using the appropriate app at the practice (2024).

	Asthmahub Users	Asthmahub for Parents Users	COPDhub Users	% Individuals with Asthma Using App	% Individuals with COPD Using App
Latitude Pearson Sig. (2-tailed) N	-0.157 <0.001 546	-0.225 <0.001 546	0.009 0.834 546	-0.184 <0.001 384	-0.086 0.092 382
Longitude Pearson Sig. (2-tailed) N	-0.044 0.300 546	-0.124 0.004 546	-0.007 0.870 546	-0.152 0.003 384	0.019 0.716 382

3.3.3 Uptake by Deprivation

Each GP practice was allocated a ranking based on the overall deprivation of the area as specified by WIMD (Welsh Government, 2019). From this, correlation analysis was undertaken to see how the uptake of the Asthmahub, Asthmahub for Parents, and COPDhub apps vary with deprivation across the whole of Wales and within each health board (Table 5).

No statistically significant relationship was found between Asthmahub uptake and deprivation across Wales in terms of the percentage of those with asthma using the app. A statistically significant correlation was observed between the percentage of individuals with COPD using the COPDhub app and deprivation ranking, indicating reduced uptake in more deprived areas, however this correlation was weak and of debatable significance.

There were no major correlations with uptake of COPDhub and deprivation in all of the health boards except for ABUHB (R Coefficient = 0.42, $p < 0.001$). No significant correlations were found in the other six health boards, indicating that the relationship between deprivation and reduced uptake is likely to be localised to ABUHB rather than present at a national level. No significant relationship was found between uptake of the Asthmahub apps and deprivation in any of the health boards.

Table 5. Correlation between WIMD Ranking (overall) and uptake of the Healthhub apps as GP practices across Wales. Uptake was defined as the number of users of each app and the percentage of individuals with asthma and COPD using the app at each GP practice. *Significant at the 0.05 level.

	Asthmahub Users	Asthmahub for Parents Users	COPDhub Users	% Individuals with Asthma Using App	% Individuals with COPD Using App
WIMD Ranking Pearson Sig. (2-tailed) N	0.089 0.038 545	0.038 0.380 545	0.047 0.269 545	0.100 0.05 385	0.128 0.012* 383

3.3.4 Uptake of the Staff-facing Dashboard

In addition to the patient facing ICST toolkit there is also the health care professional (HCP) facing All Wales ICST Platform that is available to all HCPs in Wales. As of January 2025, the dashboard was in use by a total of 14,688 HCPs across primary and secondary care in Wales. This includes 1262 GPs (60.1% of all GPs in Wales), 878 Primary care nurses (61.4% of all primary care nurses in Wales), 533 Pharmacists (19.0% of all pharmacists in Wales) and 1396 consultants (42.9% of all consultants in Wales) (Welsh Government, 2024, Welsh Government, 2024 (2)). It should also be noted that the dashboard has an exceptionally high uptake amongst respiratory consultants in Wales (estimated 90.8%) (Welsh Thoracic Society, 2024). Total users can be broken down by health board as follows:

- Aneurin Bevan University Health Board: 1989 users
- Betsi Cadwaladr University Health Board: 2350 users
- Cardiff and Vale University Health Board: 3559 users
- Cwm Taf Morgannwg University Health Board: 1849 users
- Hywel Dda University Health Board: 2243 users
- Powys Teaching Health Board: 378 users
- Swansea Bay University Health Board: 2320 users

The highest uptake in terms of total users was seen in Cardiff and Vale, with 3559 users, and the lowest in Powys Teaching Health Board, with 378 users.

3.3.4.1 Relationship between HCP uptake and patient uptake across Wales.

Regression analysis was carried out to investigate the relationship between HCP uptake in primary care, patient uptake and deprivation. The number of HCP users in primary care was found to be a significant predictor of the number of patient users at any given GP practice (adjusted R square 0.209, $p < 0.001$).

The number of registered HCPs at a GP practice was a stronger predictor of how many patients would be signed up to the app than the number of COPD and asthma patients registered at the practice ($\beta = 0.380$ and 0.171 respectively). No significant relationship was found between deprivation and the number of HCPs signed up to the All-Wales ICST Platform.

3.3.5 Engagement with GP Practices Across Wales

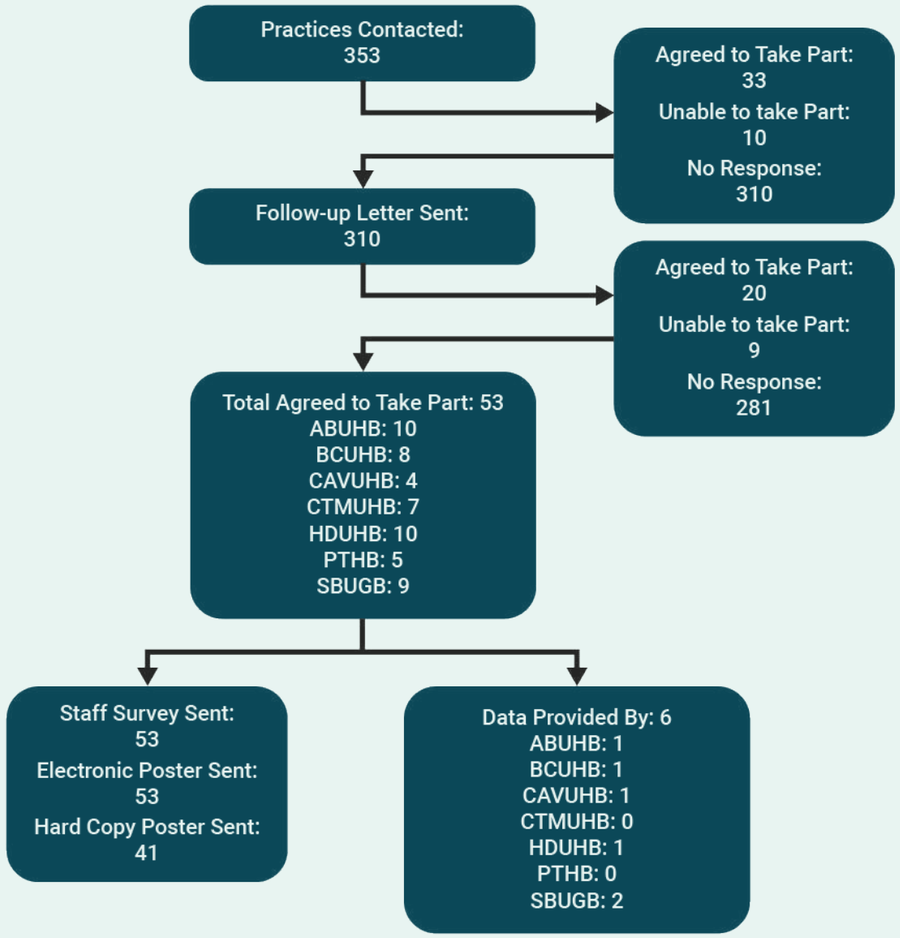
To determine the effect and impact of the ICST toolkit on primary care, GP practices across Wales were asked to take part in the evaluation. This included:

- Displaying a poster advertising the user survey in their waiting area (Appendix 6, Appendix 7).
- Disseminating the HCP survey amongst their staff.
- Providing data on the scheduled and unscheduled GP appointments related to COPD and Asthma (Appendix 11).

A summary of the GP practices that took part in each health board is shown below.

The majority of practices (around 80%) did not engage with the evaluation. Follow-up phone calls were made to several non-responsive practices to encourage participation, but this was largely unsuccessful. Continued follow-ups were abandoned due to impracticality within the given time frames for the evaluation. The most common reasons for non-participation were a lack of resources or capacity, particularly in fulfilling the data request. Data was provided by six practices (see section 3.5).

Figure 3. Summary of GP practice engagement across Wales.



3.4 Impact of the Toolkit on Patients

3.4.1 Patient Reported Experience Measures (PREMs)

3.4.1.1 ICST Healthhub Survey 2023

In 2023 ICST carried out a survey via the Healthhub apps, with the aim of determining if the apps are helping individuals to manage their condition (see Appendix 4 for details of the survey). The survey was sent to users of all three apps for completion (n ~ 10,000) with a response rate of just under 4% (n=371).

When asked how long they had been using the app, the majority of responders noted they had used the app for more than 6 months (51%, n = 371, response rate ~ 3.71%), with 26% of responders using the app for more than 12 months (see Figure 4). When asked how often they are using the app, the most common response was that they use the app less than once a month (43% of respondents, n = 366, response rate ~ 3.66%) (see Figure 4).

To determine the perceived impact of the app on the user's ability to manage their condition, users were asked how well their condition was managed prior to downloading the app, and how well their condition was managed since downloading the app (on a scale of 1 to 10). The response rate to the question was around 3.57% (357 responses). Responses showed a significant improvement in the patients perceived ability to manage their condition since downloading the app ($p < 0.001$, Wilcoxon Signed Rank Test) (see Figure 5).

As part of the survey, users were asked if their number of GP visits had increased or decreased since using the app. The response rate was around 3.68% (n = 368), with 82 (22%) indicating that their number of visits to the GP had decreased, 214 (58%) indicating their number of visits to the GP had not changed, 24 (7%) indicating that their number of visits to the GP had increased, and 48 (13%) stating 'other', the majority of which stated they haven't needed to see a GP (Figure 6).

Users were also asked if their number of admissions to the ED had increased or decreased since using the app. The response rate was around 3.67% (n = 367), with 58 (16%) indicating that their number of admissions to the ED had decreased, 174 (47%) indicating their number of admissions had not changed, 7 (2%) indicating that their number of admissions to the ED had increased, and 128 (35%) answering 'other', the majority of which stated they hadn't had any admissions to ED (Figure 6).

Figure 4. Graph showing responses from users when asked how long they had been using the app, and how often they were using the app (Healthhub survey 2023).

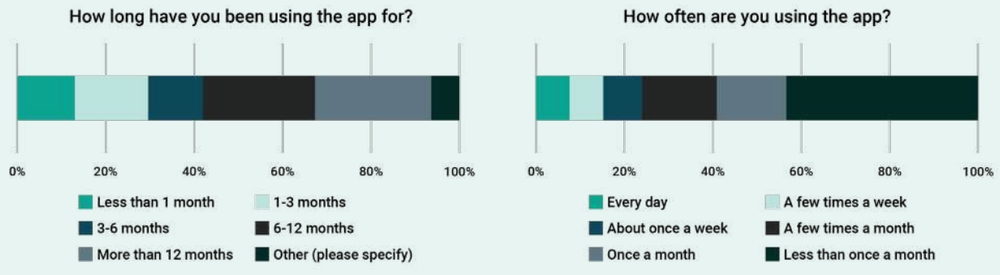


Figure 5. Graph showing how users answered when asked how well their condition was managed before downloading the app and since downloading the app (Healthhub Survey 2023). Data presented as median (IQR).

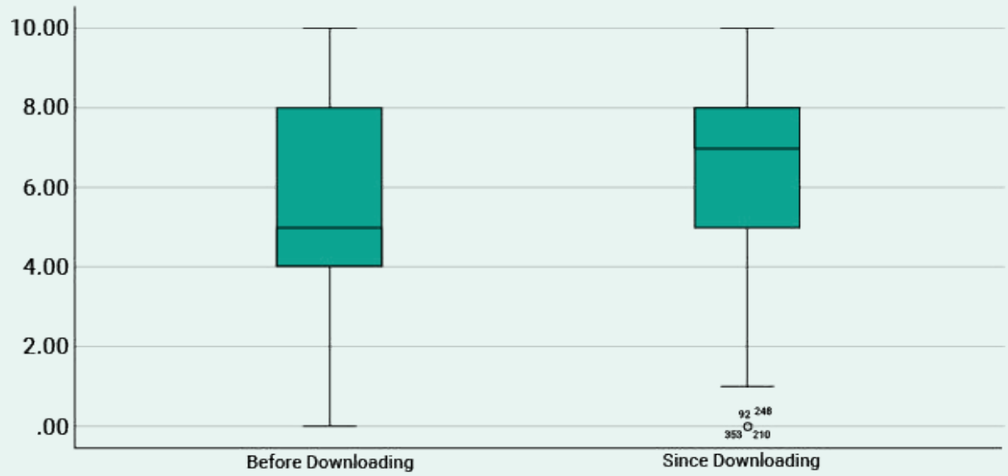
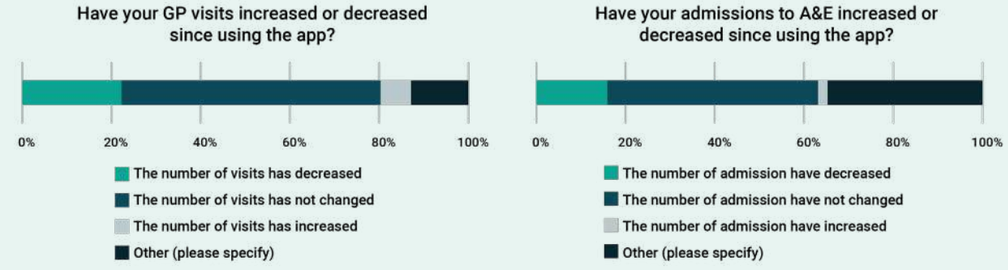


Figure 6. Graph showing responses from app users when asked if their GP visits or A&E admissions had decreased or increased since using the app (Healthhub survey 2023).



3.4.1.2 TriTech Institute/ATiC Healthhub Survey 2024

A key part of the evaluation involved commissioning a secondary independent survey of the Healthhub app users. The survey was carried out by The TriTech Institute and the Assistive Technologies Innovation Centre (ATiC) in October 2024. The survey was distributed to GP practices across Wales that agreed to take part in the evaluation through a poster containing the QR code survey link, with digital and hard copies available for the GP practices to display. The poster was also shared on social media, and networks of respiratory health care professionals were asked to share the survey with their asthma and COPD patients. In addition, a link to the survey was also sent to all Healthhub app users through the Healthhub apps, via ICST.

3.4.1.2.1 Analysis of non-app users

Out of the survey respondents (disseminated through GP practices), 43 were non-app users (i.e., they had never used any of the Healthhub apps). However, as this is a small subset compared to the wider dataset, caution is needed when generalising these results. However, the feedback from non-responders offers valuable insights into why people have not engaged with the Healthhub apps. Table 6 highlights the reasons for not using the apps, with the primary reason being a lack of awareness about the Healthhub apps.

Table 6. Responses to the question "Please tell us why you never use the Health Hub Apps?"

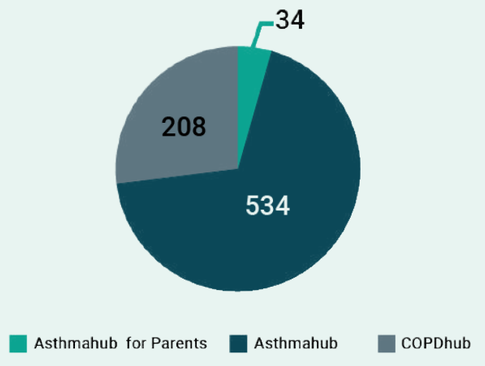
Reason given	n
Not aware/have never heard of it	33 (76.7%)
I do not like using apps	0
I was advised not to use it by my health professional	1 (2.3%)
I do not think I need to use the app	4 (9.3%)
Other (n=3)	Can't be bothered Forget about them Was not useful when using for two people (i.e. my myself and child)

3.4.1.2.2 Analysis of App Users

Use of different Health Hub Apps

A total of 780 responses were collected from users of the Healthhub apps. The majority of respondents reported using the Asthmahub app (n=534), followed by the COPDhub app (n=208), with the fewest respondents using the Asthmahub for Parents app (n=34) (Figure 7). A small number of respondents (n=25, less than 5% of the total dataset) used more than one of these Healthhub apps. Three-quarters of respondents (n=561) learned about their app from their healthcare professional, while an additional 13% (n=99) discovered it through an online search.

Figure 7. Respondents by app use (Healthhub survey 2024).



App usage

Of the 780 responses, over 70% of users have been using the app for more than six months. Approximately 12% have used the app for 4-6 months, 8% for 1-3 months, and another 8% for less than one month. Additionally, 77% of respondents reported using the app "as and when required," about 12% use it monthly, 6% use it weekly, and 5% use it daily.

Overall Satisfaction

Most participants expressed satisfaction with their overall experience using the app. 68.5% (n=481) of respondents said they would recommend the Healthhub apps to others with respiratory conditions, while only 7.8% (n=55) stated they would not recommend it.

When asked about their level of satisfaction with the app just over half (52.1%) indicated that they were satisfied: around 12.5% of the 659 respondents answering this question stated they were not satisfied, the remaining third of respondents (35.4%) selected a "neutral" response. Figures 8 and 9 illustrate the breakdown of these questions by specific app, revealing a consistent pattern across all apps. While most participants would recommend the Healthhub apps to other users, there may still be aspects of the apps that users are not completely satisfied with.

Figure 8. Responses when asked if users would recommend the app to others with respiratory conditions. Data presented by Healthhub app.

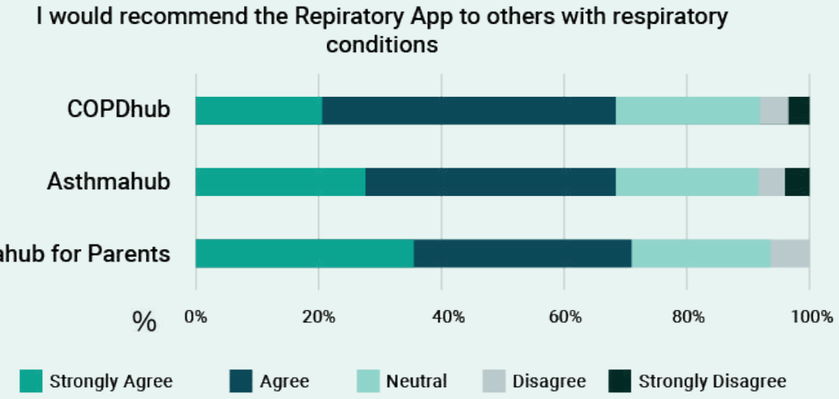
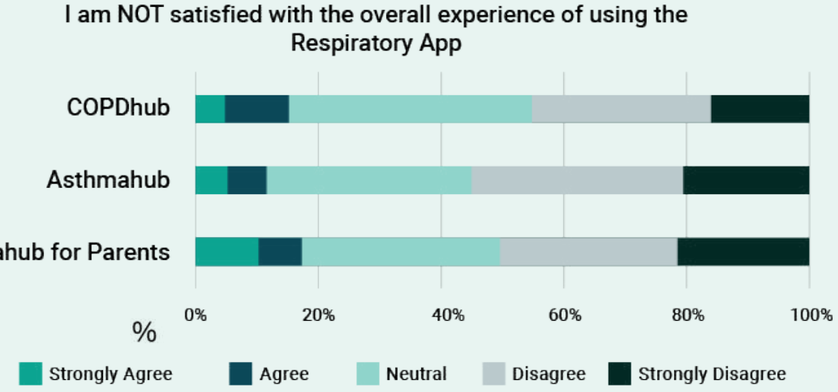


Figure 9. Responses when asked if users are NOT satisfied with the overall experience of using the app. Data presented by Healthhub app.



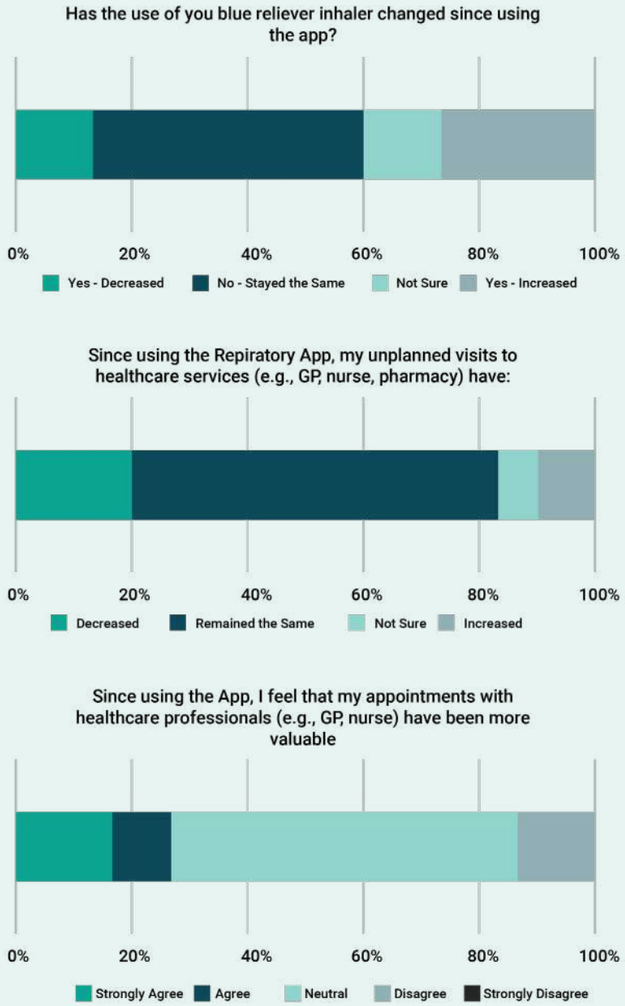
3.4.1.2.3 Responses to behavioural questions split by App

3.4.1.2.3.1 Asthmahub for Parents (n=31)

Health-related behaviours

Just under half of respondents (n=14, 46.7%) stated that their use of their blue respiratory inhaler had not changed despite using the app. Blue inhaler use increased for 26.7% respondents and decreased for 13.3% of responders. In relation to visiting clinical services, 63.3% of respondents stated the number of visits had remained the same whilst 20% stated visits had decreased and 10% stated that visits had increased. Finally, 60% of respondents stated that they were unsure whether their appointments with healthcare professionals had become more valuable since using the app with 26.7% of responders stating that they had become more valuable and 13.3% stating that they had not become more valuable.

Figure 10. Asthmahub for parents: percentage of respondents agreeing with health-related statements.



COM-B Questions

The following questions in the patient survey mapped onto the specific domains of the Behaviour Change Wheel's COM-B model as shown in Table 7.

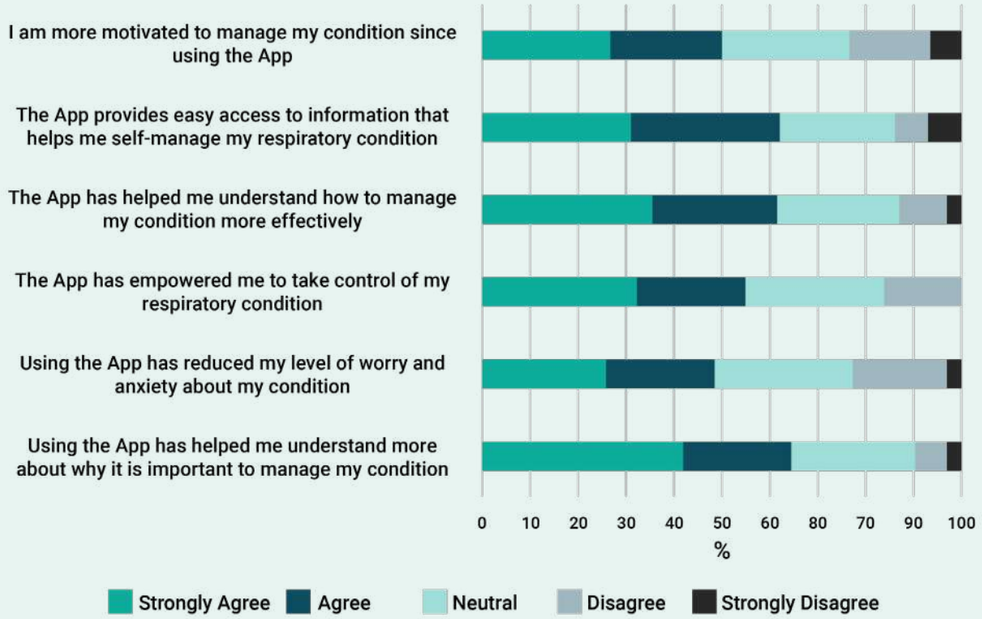
Figure 11 presents the percentage of responses for each of the COM-B questions related to the Asthmahub for Parents app. The findings suggest that engagement with the app enhanced perceptions of capability among most respondents. Specifically, 62% reported an increased understanding of the importance of managing the condition, and 61.3% felt it helped them understand how to manage it. Just under half (48.4%) agreed that the app helped reduce their worry and concern about their condition.

Table 7. Specific behaviour change questions mapped to the COM-B model.

COM-B mapped to Respiratory App	Survey Question
Capability	
Have a better understanding of why self-management of your respiratory condition is important	Using the App has helped me understand more about why it is important to manage my condition
Understand the processes and procedures involved in self-management	The App has helped me understand how to manage my condition more effectively
Manage own stress and negative feelings/ Learn how to manage the cognitive and emotional impact of engaging with self-management behaviours	Using the App has reduced my level of worry and anxiety about my condition
Opportunity	
Have more reminders at strategic times of importance of self-management	The App provides easy access to information that helps me self-manage my respiratory condition
Motivation	
Feel more of a sense of satisfaction from using the App	I am more motivated to manage my condition since using the App

Additionally, 62% of respondents agreed that the app increased their opportunity to change health behaviours by providing easy access to self-management information. Finally, half of the respondents indicated that using the Asthmahub for Parents app made them more motivated to manage their condition(s). However, due to the small number of respondents using the Asthmahub for Parents app, this data should be interpreted with caution. There is potential ambiguity in the responses, as the questions may have captured parental experiences rather than patient perspectives.

Figure 11. Asthmahub for parents: percentage of respondents agreeing to each statement.



3.4.1.2.3.2 Asthmahub (n = 506)

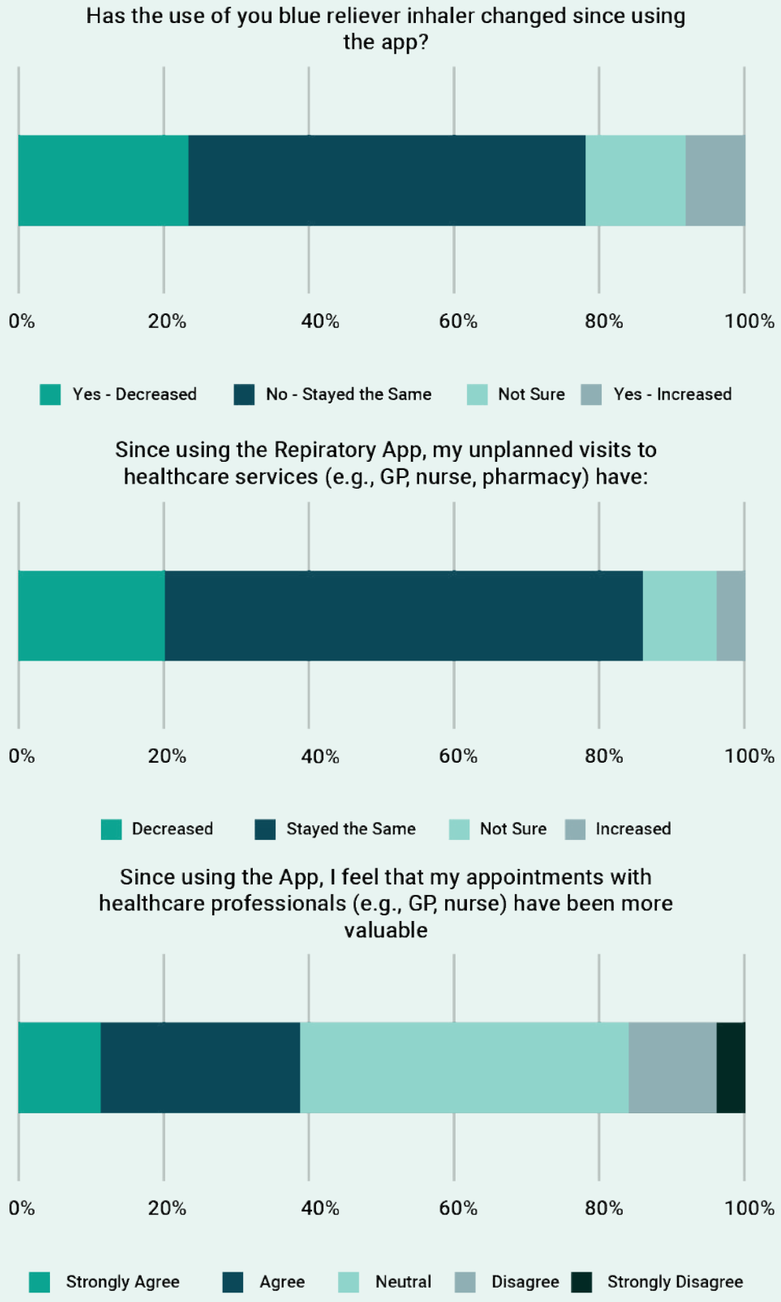
Health-related behaviours

Just over half of respondents (n=257, 54.7%) stated that their use of their respiratory inhaler had not changed since using the app. Inhaler use increased for 6.7% of respondents and decreased for just under a quarter of respondents (23.6%), a net reduction in inhaler use of around 17%.

In relation to using other clinical services, two-thirds of respondents stated the number of visits had remained the same whilst 20.3% stated visits had decreased and 3.8% stated that they had increased, a net reduction of 16.5%.

Finally, 45.5% of responders stated that they were unsure whether their appointments with healthcare professionals had become more valuable since using the app. 38.8% of responders stating that they had become more valuable with 15.7% stating they had become less valuable.

Figure 12. Asthmahub: percentage of respondents agreeing with health-related statements.



COM-B questions:
Asthmahub app users gave the highest level of positive endorsement (65.4%) to the increased opportunity to change their health behaviours, thanks to the easy access to information that helps them self-manage their respiratory condition. This was followed by increased capability through helping them understand more about the importance of managing their condition (56.7%). Half (49.2%) of respondents also agreed or strongly agreed that the app had helped improve their capability to change their behaviour by helping them understand how to manage their condition more effectively.

3.4.1.2.3.3 COPDhub (n = 185)

Health-related behaviours
More than half of the respondents (58.8%) reported that their use of their respiratory inhaler remained unchanged since they started using the app. Inhaler use increased for 12.9% respondents and decreased for 16.4%, a net reduction of 3.5%. In relation to visiting clinical services, 70.3% of respondents stated the number of visits had remained the same whilst 16.4% stated visits had decreased and 7.2% stated that had increased, a net reduction of 9%. Finally, 44.1% of respondents stated that they were unsure whether their appointments with healthcare professionals had become more valuable since using the app with 40.3% stating that they had become more valuable and 15.4% stating they had become less valuable.

Figure 13. Asthmahub: percentage of respondents agreeing to each statement.

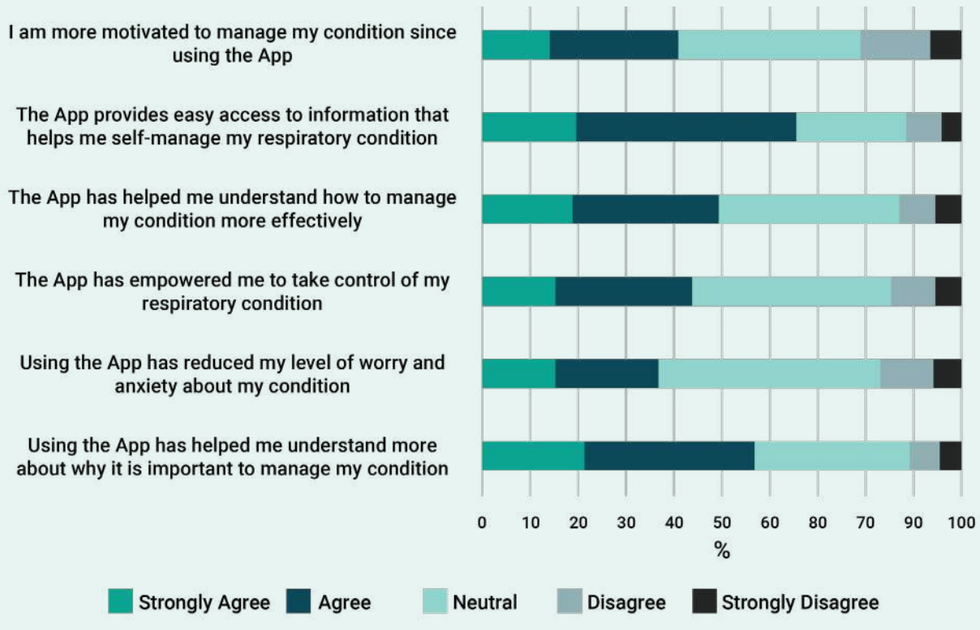
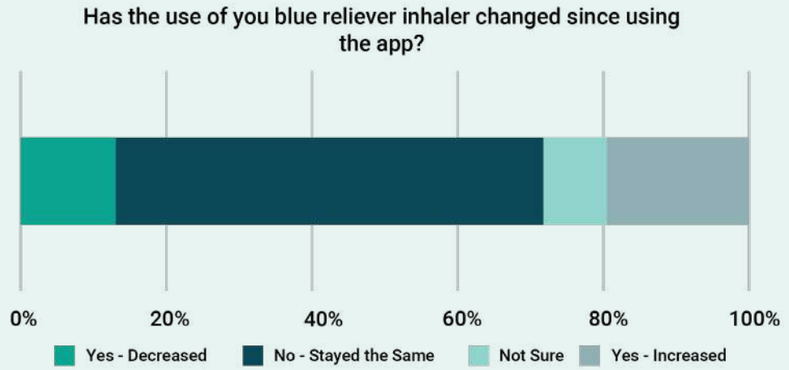
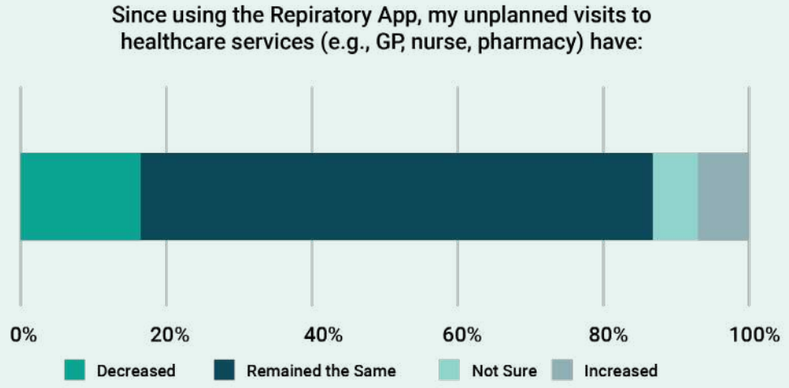
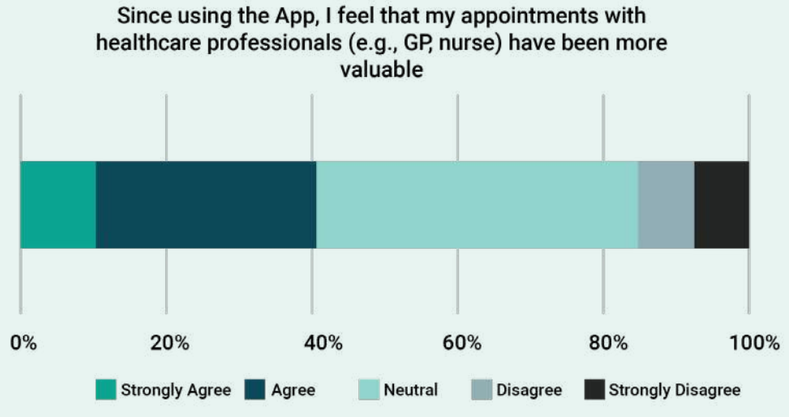


Figure 14. COPDhub: answers to health-related questions.



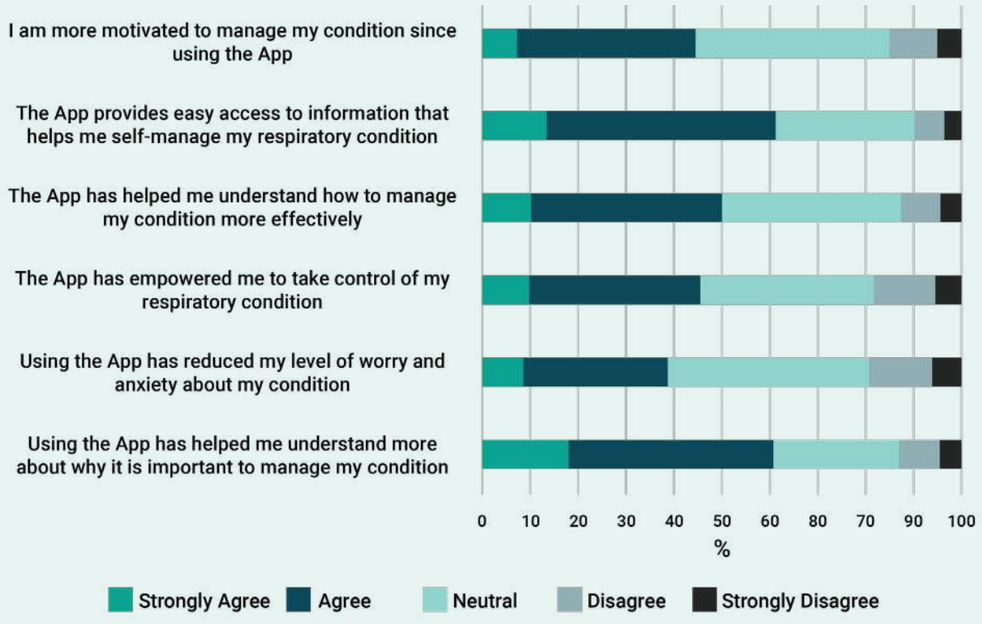




COM-B questions

As shown in Figure 14, the responses to the COM-B questions for the COPDhub app mirrored the pattern observed with the Asthmahub app. Again, the highest level of positive endorsement in the COPDhub app users was the increased opportunity to change their health behaviours through providing easy access to information that helps them self-manage their respiratory condition (60.8%). Increased capability through helping them understand more about the importance of managing their condition (61%) was also important. Half of respondents agreed or strongly agreed that the app had helped them understand how to manage their condition more effectively.

Figure 15. COPDhub: Percentage of respondents agreeing to each question.



3.4.1.2.4 Analysis of Free Text Comments

Free text comments highlighted the positive aspects of the apps, with patients noting the useful hints and tips provided, as well as the increased understanding of how to manage their condition.

Helped me understand since I have suffered with the condition (p226, Asthmahub user)

Some useful tips about managing my condition in colder months (p227, Asthmahub user)

The app has given me a lot of information and guidance. It helps me control my symptoms (p26, Asthmahub user)

Some patients also reported how they found it useful to monitor and record their health data.

Helpful for keeping up to date results when using app and have a record of my progress (p860. Asthmahub user)

I find the app really useful for logging my peak flow readings and I can show them when seeing my GP or asthma nurse. The information on the app is helpful too (p544, Asthmahub Parents)

Conversely, free text comments shed light on the neutral responses to some survey questions. Many of these comments pointed to technical issues with the app, as noted in the UX section of this report, and highlighted that some patients did not fully understand the purpose or function of the apps.

I'm not entirely sure what it's for! I would prefer a face-to-face appointment every time but of course those are very hard to come by (P44, Asthmahub user)

The app hasn't given me any more information than my health care provider (P53, Asthmahub user)

It had made no impact on my asthma management (p170, Asthmahub user).

Negative free text comments were also noted. These primarily focused on people not using the app despite having it. Additionally, some patients felt they already had a good understanding of their condition and how to manage it, or they believed they received sufficient care from their healthcare professionals.

I believe I already had a good understanding of my condition; I believe to direct patients to the hub should not supplement a face-to-face appointment (p392, Asthmahub user)

Have always managed my asthma well, the app was to keep the respiratory nurse at my surgery happy (P348, Asthmahub user)

The asthma nurse is so knowledgeable and helpful that the app isn't needed as much (p364, Asthmahub parents and Asthmahub apps user)

The apps may therefore be seen as more useful to patients who do not feel they have regular/effective communication with their GP, practice nurse or other health professional.

I use the app because I can't remember the last time, I saw a health care person at my surgery (p436, Asthmahub for parents)

App is my support, difficult to see doctors, given rescue packs without seeing anyone (p445, COPDhub user)

When I'm unable to see a doctor (which is always) I refer to the app for help! It's brilliant thank you (P732, Asthmahub user)

3.4.2 Patient Recorded Outcome Measures (PROMs)

3.4.2.1 Asthmahub

3.4.2.1.1 Asthmachecker Questions

As part of the ongoing management of their condition, users of the Asthmahub app were asked 10 questions (on a routine basis) to evaluate their asthma control, consisting of reliever inhaler usage, GP visits, A&E admissions, steroid prescriptions and the RCP three question validated tool (Appendix 8). Data from ICST shows that 6001 (50%) users of Asthmahub had completed at least one asthma checker survey from January 2022 to May 2024. The majority of these (n = 3,763, 63.7%) only completed the asthma checker survey once, 1,145 (19.1%) completed the asthma checker survey twice, with 1,093 (18.2%) completing the survey three or more times.

In the Asthma checker, users with a peak flow over 80% and positive responses to all 10 questions are categorised as having 'good' control. Figure 16 displays data on the percentage of Asthmahub users with 'good' control over their symptoms from January 2022 to May 2024. The raw data indicates no increase in the overall percentage of respondents exhibiting 'good' control during this period.

One positive outcome from the Asthma checker is an increase over time of app users reporting that they do not need to use their reliever inhaler (Figure 17). The yearly totals indicate an increase in the percent of Asthmahub users reporting not needing to use their reliever inhaler, from 27.6% in 2022 to 33.7% in 2023 to 34.4% in 2024. However, as most only enter data once, the overall trends should be treated with caution, as there are different individuals entering values over time.

To overcome the limitation of different users responding to the survey over time, improvement in a user's ability to manage their condition can be assessed by comparing the data of users who have completed more than one Asthma Checker survey. Results for users who completed the survey at least twice (n=2,238) were analysed to determine if there was an improvement from using the app. Wilcoxon Signed Rank Test indicated a significant increase in the asthma checker score at the second completion (p = 0.023). As can be seen in figure 18 below, there were 752 increases in asthma checker score, 664 decreases and 882 ties from completion 1 to completion 2. These results are indicative of overall improved asthma control after a median of 1 month using the Asthmahub app.

Figure 16. Percentage of Asthmahub users over time indicating a 'good' control of their condition.

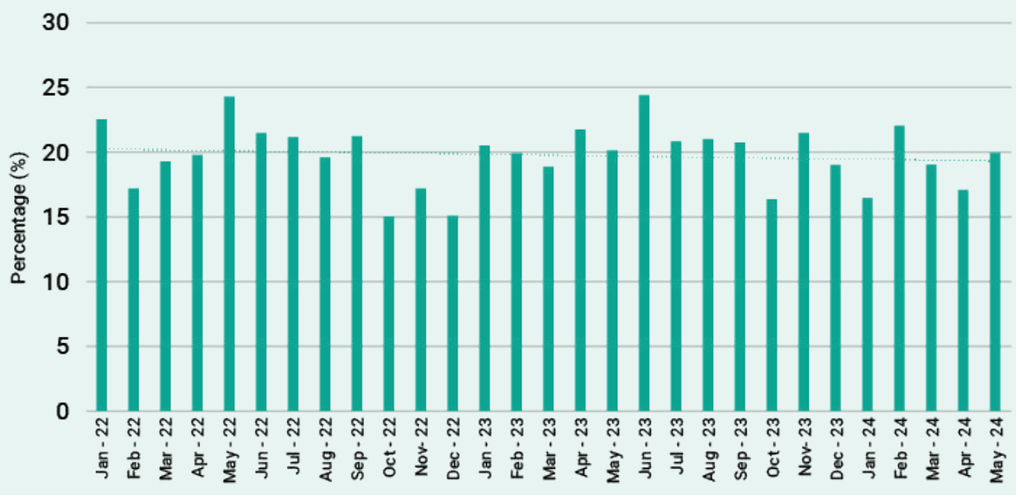


Figure 17. Percentage of Asthmahub users over time that reported not needed to use their reliever inhaler in the previous month.

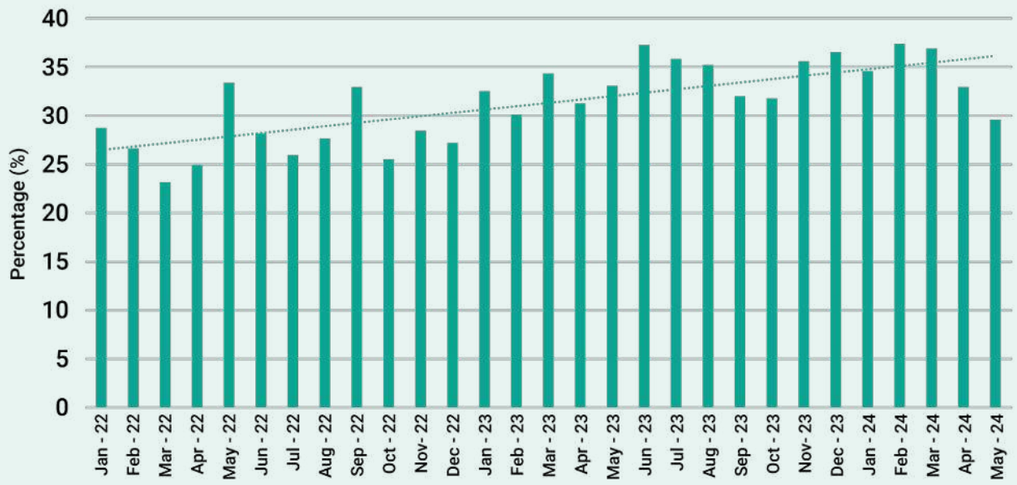
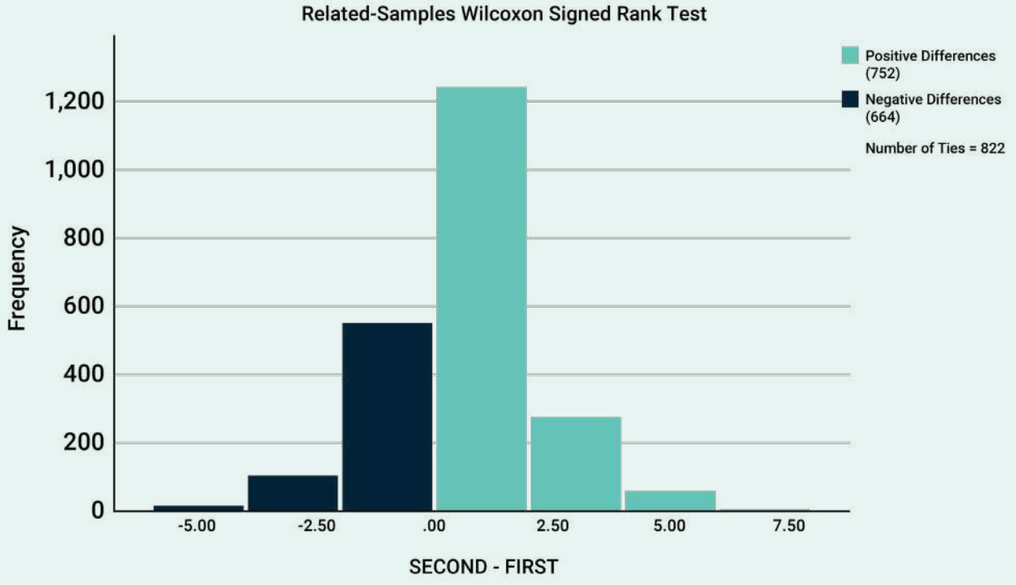


Figure 18. Positive and negative differences between first and second asthma checker completion. Data provided by ICST.



3.4.2.1.2 Royal College of Physicians 3 Questions (RCP3Q)

As part of the monthly Asthma Checker questionnaire, users are asked to complete the RCP3Q PROM (Appendix 8, Question 10 RCP1-3). The RCP3Q has four possible scores that indicate the level of asthma control as follows (Pinnock et al., 2012):

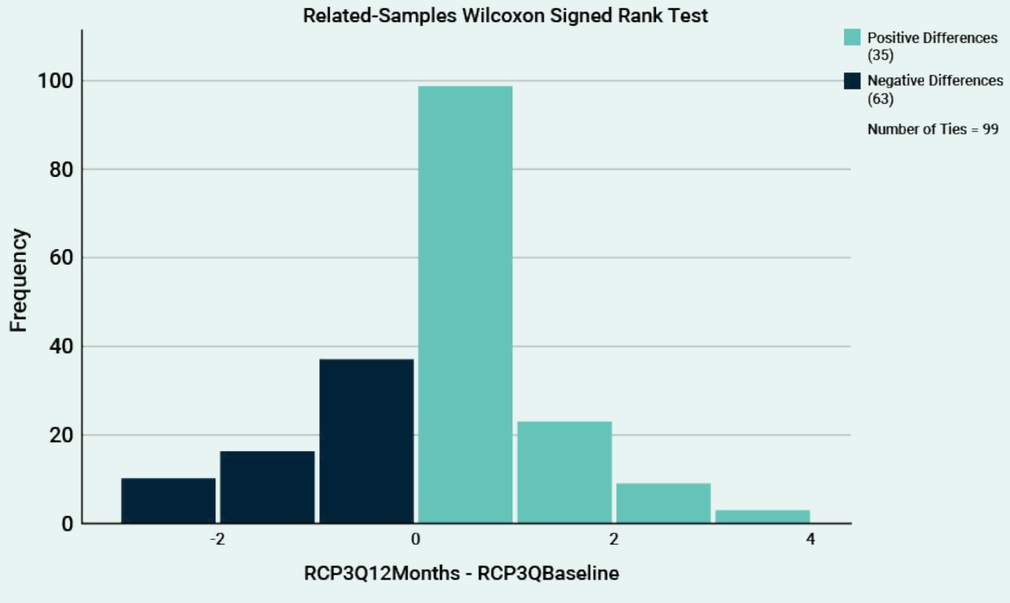
- 0 = good control.
- 1 = potential suboptimal control requiring further investigation.
- 2 = poor control.
- 3 = poor control.

Data provided by ICST included users that had completed a baseline RCP3Q score, and a score 12 or 13 months later, to allow for a comparison of asthma control at baseline and at 1 year follow-up (n = 198). The data shows that the RCP3Q was significantly improved at 12/13 months (p = 0.004, Wilcoxon Signed Rank Test).

Table 8. Frequency of RCP3Q responses at baseline and at 12/13 months. Data presented as frequency and percent of total responses.

	Baseline RCP3Q		12/13 Month RCQ3Q	
Capability	Frequency	Percent	Frequency	Percent
0	62	31.5	82	41.6
1	49	24.9	43	21.8
2	36	18.3	37	18.8
3	50	25.4	35	17.8
Total	197	100.0	197	100.0

Figure 19. Frequency of positive and negative differences between Baseline and 12/13 Month RCP3Q values.

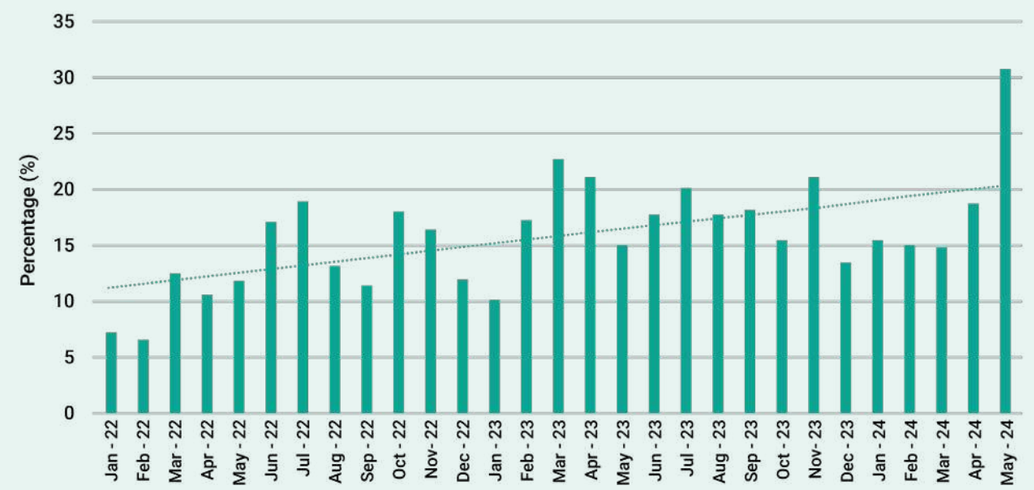


3.4.2.2 COPDhub

3.4.2.2.1 COPD Checker

Similarly to the Asthmahub app, COPDhub users are asked to complete their COPD checker on a monthly basis, where they are asked 12 questions regarding the management of their condition, with those answering positively for all questions categorised as having 'good' control of their condition (Appendix 9). The percentage of individuals reporting 'good' control of their condition increased over time from Jan-22 to May-24 (Figure 20). However, it is also important to note that COPD is a progressive condition, and any intervention would only be expected to slow the progression of the disease.

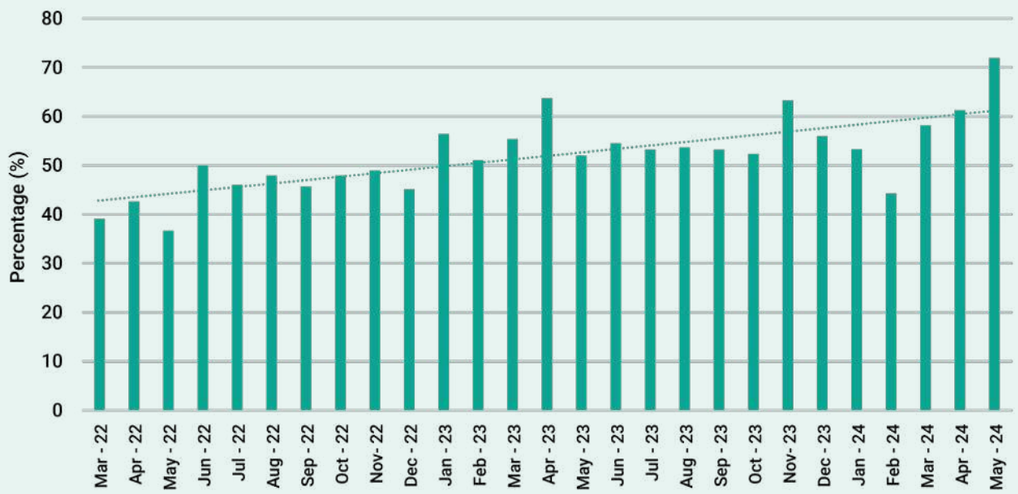
Figure 20. Percentage of COPDhub users over time indicating a 'good' control of their condition.



COPDhub Reliever Inhaler Use

In the COPD Checker, users are asked, "Are you using your reliever inhaler daily, or more often than you would normally?" An increasing proportion of respondents are reporting that they do not need to use their reliever inhaler every day or more frequently than usual (Figure 21). The yearly totals indicate an increase in the percentage of COPDhub users reporting not using their inhaler daily or more often that they would normally, from 45.6% in 2022 to 55.4% in 2023 to 55.3% in 2024. However, the number of responses is small by comparison, with a median number of responses per month = 77 (IQR 65.5, 85.5)

Figure 21. Percentage of COPD hub users over time that reported not using their relieved inhaler every day, or more often than usual.



3.4.3 Patient Interviews

3.4.3.1 Patient Final Themes:

As part of the evaluation, patients using the different apps were invited to participate in interviews through the Healthhub 2024 survey advertisements. In total 8 users were interviewed (5 for Asthmahub, 1 for Asthmahub for parents and 2 for COPDhub). The interviews were transcribed, and a thematic analysis was carried out on the responses. Below is a list of the key themes that were derived from the interviews: A representation of the themes from the interviews can be seen in figure 22. Details of the key themes can be seen below:

Theme 1. Empowering Patients to Take Charge

The Healthhub apps play a transformative role in empowering patients to manage their respiratory health independently and confidently. Features like peak flow monitoring and medication tracking provide patients with actionable insights into their health, enabling them to identify trends and anticipate potential issues. This proactive approach allows patients to seek clinical support only when necessary, while ensuring they can communicate their symptoms effectively during consultations.

By deepening their understanding of medications and symptom control, the Healthhub app fosters a sense of ownership over their condition. Patients feel equipped to navigate their health journey without over-reliance on external interventions. Tools such as free text entries and trend data help patients document their experiences and share these insights with healthcare providers, enabling more informed decision-making. In this way, the Healthhub app not only supports patients in achieving better health outcomes but also strengthens the efficiency of professional care.

"We don't have proper medical care in our area. The GP surgery is the blockage in the system... The app is the most information I've had for a long time – a lifeline!"

(43 year old patient with asthma)

Theme 2. Effortless Use, Hidden Hurdles

The Healthhub apps are widely regarded as intuitive and easy to use, especially by those with some familiarity with digital tools. Features like seamless phone data transfer and a straightforward interface enable users to navigate the apps efficiently, making them an accessible and valuable resource for managing respiratory health. Many patients report that after a short adjustment period, the Healthhub App becomes a reliable part of their routine.

However, usability challenges persist for some users, particularly those new to technology or less familiar with digital health tools. Onboarding processes could be improved, as new users often struggle to discover and utilise key features like peak flow diaries and trend lines. Design elements such as unclear question phrasing and the absence of a "Not Applicable" option can also hinder engagement. Moreover, it was reported that the Healthhub apps currently lack the capability to track certain types of inhalers, such as dual "preventer and steroid" combinations (e.g., "Fostair"), which limits the functionality of the apps for a subset of users. However, this functionality is present in the apps, suggesting better onboarding support, more intuitive layouts, and enhanced feature flexibility would broaden the Healthhub App's usability and impact.

Theme 3. Unlocking the Potential of Key Features

While core features like peak flow monitoring and medication tracking are well-utilised and valued, other functionalities of the Healthhub apps remain underexplored. Educational resources and wellness dials, for instance, are often overlooked due to their lower visibility or perceived irrelevance to daily health management. This highlights a gap in how the Apps communicate the value of their features to users. Patients suggested several enhancements to address this challenge. For example, visual cues or prompts could draw attention to underused features, such as educational videos or inhaler technique guides. Symptom alerts tied to data from peak flow monitoring or self-reported symptoms could encourage patients to act earlier by consulting their GP or managing exacerbations proactively. By ensuring every feature of the apps is accessible, relevant, and well-integrated, the utility of the apps can be maximised to provide a more comprehensive tool for respiratory care.

"It was advising on what to do if my peak flow meter readings went below a certain level and how I could deal with that."

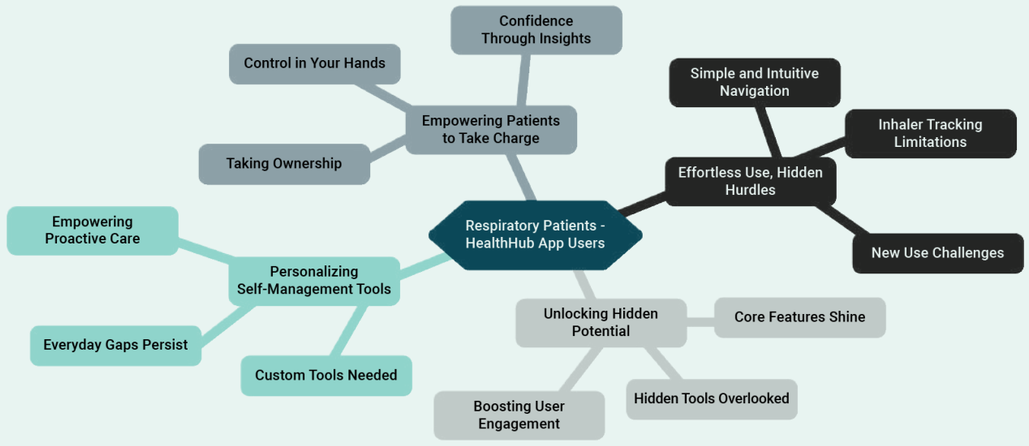
(70 year old patient with asthma)

Theme 4. Personalizing Self-Management Tool
The effectiveness of the apps in supporting self-management varies across the diverse user base, reflecting the differing needs, preferences, and conditions of patients. For some, the apps serve as an indispensable tool, enabling them to track symptoms, adjust medications, and engage in productive consultations with healthcare professionals. For others, particularly those with well-controlled symptoms or alternative management strategies, the Healthhub apps feels less central to their daily care routines. To better cater to this range of needs, the apps could introduce greater customisation options. Features allowing patients to tailor notifications, set personal goals, or focus on specific health concerns—such as stress-induced asthma or exacerbation triggers—would enhance the relevance of the apps. Additional tools, such as prompts for managing exacerbations or environmental tracking (e.g., air quality), could further support personalised care. By aligning with the unique circumstances of each user, the Healthhub apps have the potential to evolve into a dynamic and inclusive platform that adapts to the varied journeys of respiratory patients.

"I really like being able to log my peak flow tests. It's helping me learn how to manage my asthma... Showing me, 'this is stable,' or 'this is good."

(43 year old patient with asthma)

Figure 22. Representation of final themes and associated sub-themes from patient interviews.



3.5 Effect of the toolkit on patient outcomes

3.5.1 The Picture Across Wales

The demand for respiratory services has been increasing across Wales since 2020. The mean number of respiratory-related emergency department (ED) attendances increased from 4,796 in 2020 to 6,405 in 2024 (see figure 23). This could be in part due to increased respiratory infections due to the COVID pandemic. Additionally, a reduced number of attendances in 2020 could reflect the reduced transmission of viruses that trigger acute exacerbation of COPD or asthma due to COVID measures. Similarly, the number of hospital admissions due to respiratory illness has increased since 2020 (see figure 24).

Figure 23. Mean number of ED attendances for respiratory conditions per month by health board (data provided by DHCW).

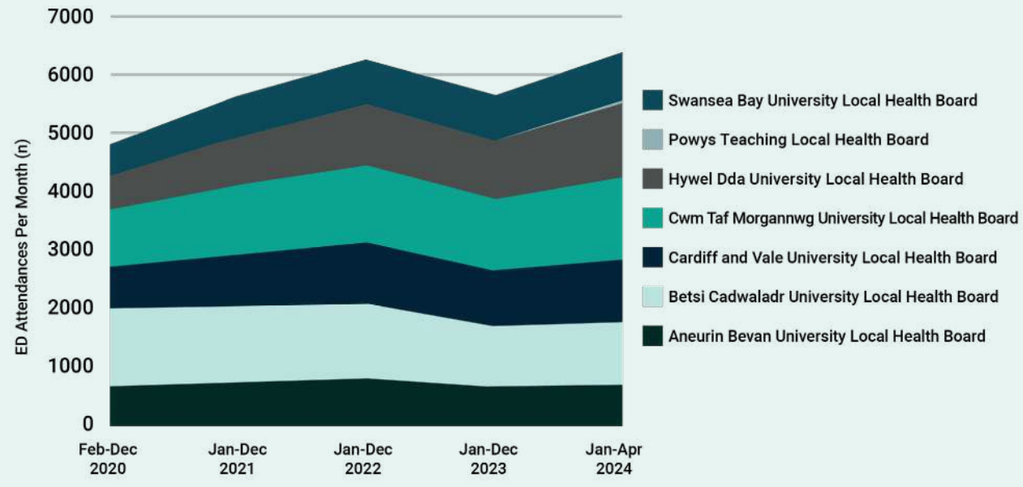
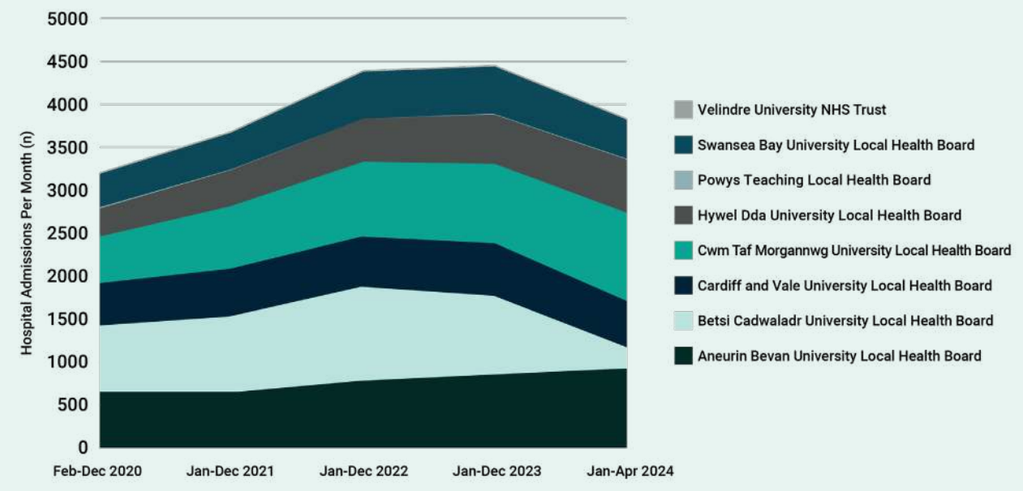


Figure 24. Mean number of hospital admissions for respiratory conditions per month by health board (data provided by DHCW).



Mean hospital admissions per month due to respiratory illness increased from 3196 per month in Feb-Dec 2020 to 3869 per month in Jan-April 2024. This increase was primarily due to COPD admissions which have increased steadily from 2020 (466 admissions/month) to 2023 (542 admissions/month) (see Figure 26). The mean number of hospital admissions per month due to asthma has not changed greatly since 2020, with a mean number of admissions of 206 per month for the period Feb-Dec 2020 (see Figure 25). In the first 4 months of 2024, the mean number of admissions per month in Wales due to asthma was 184, however, there could be seasonal factors which lead to increased asthma-related complications. Similarly to ED attendances, a lower level of hospital admissions during 2020 could be due to the impact of COVID measures in place, reducing the transmission of viruses that could trigger an acute exacerbation of COPD or asthma.

Respiratory-related outpatient appointments have increased since 2020, with around 8,739 respiratory outpatient appointments per month in Feb-Dec 2020, which has increased to 12,540 per month in Jan-April 2024 (see Figure 27). This increase could be due to the effect of the COVID-19 pandemic, which reduced appointments in 2020 and 2021.

The total number of prescriptions issued for salbutamol in Wales has decreased from 1,819,626 in the year April 2019-March 2020 to 1,715,478 in the year April 2022-March 2023. Indicating a reduction in inhaler use/prescription over the period.

Figure 25. Mean hospital admissions per month due to asthma per month by health board (data provided by DHCW).

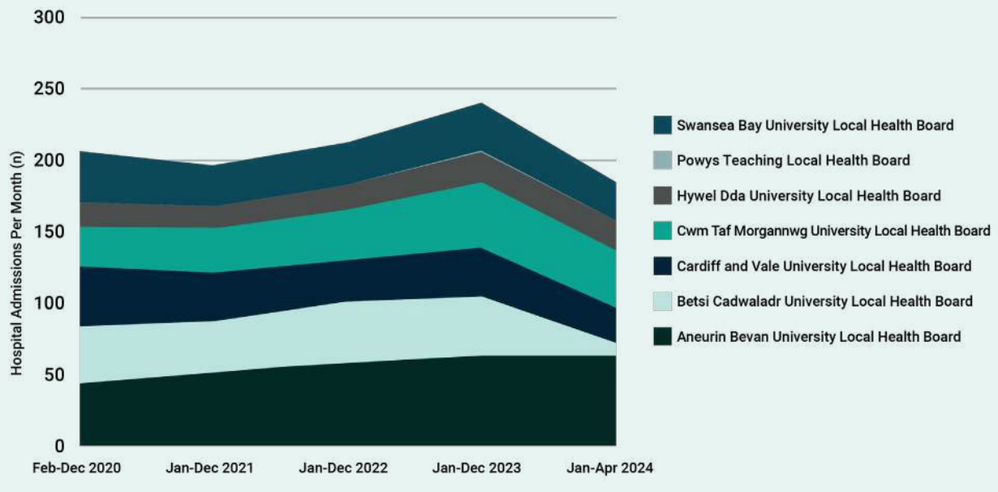


Figure 26. Mean hospital admissions per month due to COPD per month by health board (data provided by DHCW).

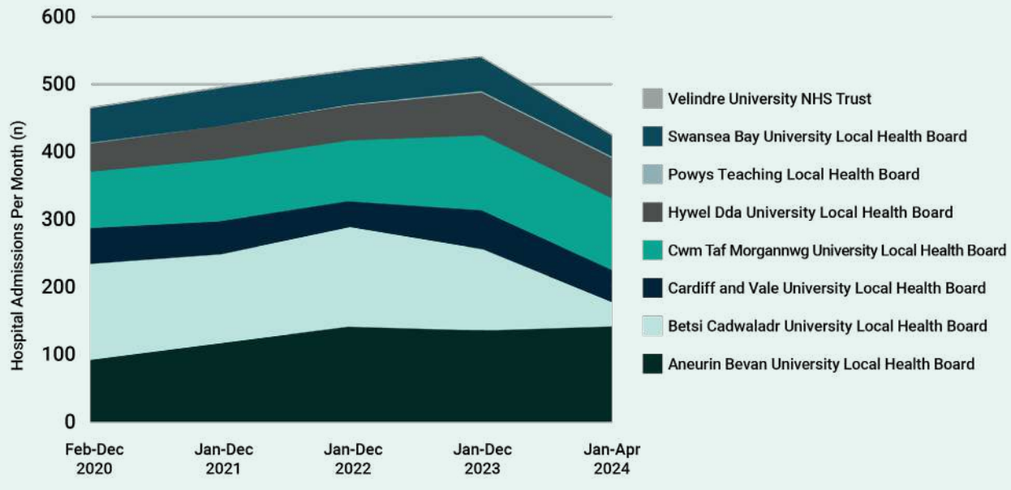


Figure 27. Primary prescriptions issued for salbutamol in Wales by health board yearly from April 2019 to March 2023 (data provided by DHCW).

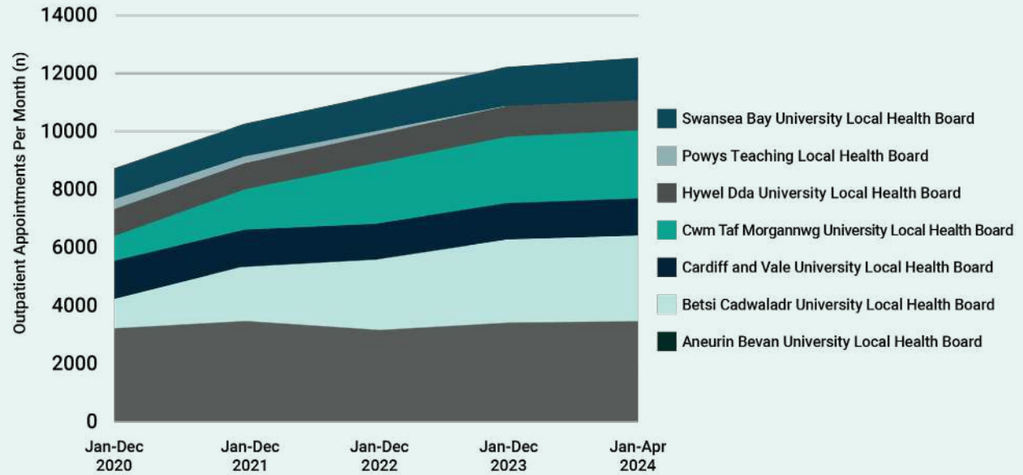
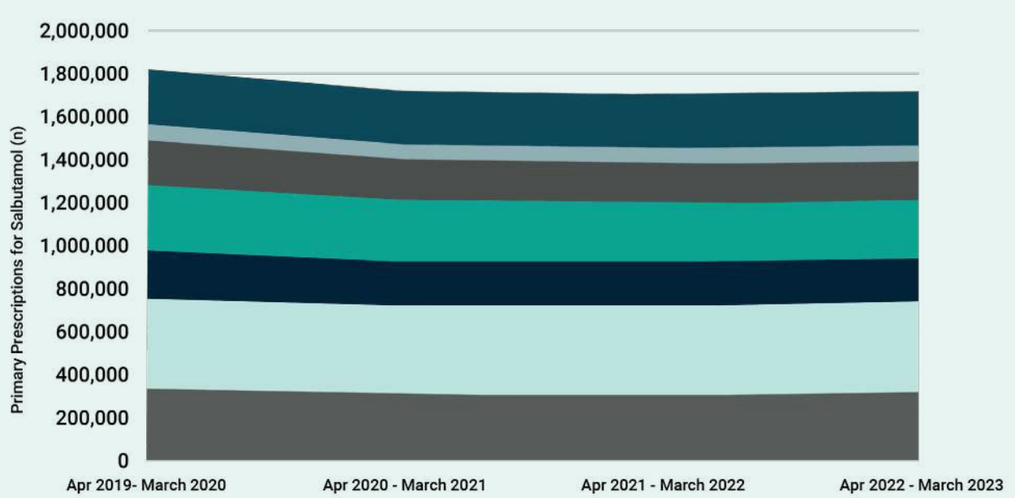


Figure 28. Primary prescriptions issued for salbutamol in Wales by health board yearly from April 2019 to March 2023 (data provided by DHCW).

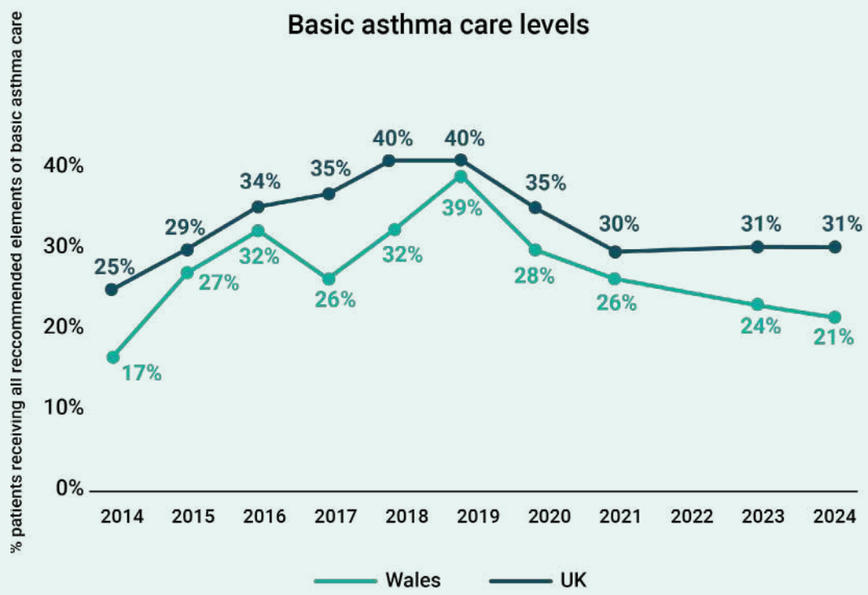


3.5.1.1 The Level of Asthma and COPD Care in Wales

3.5.1.1.2 Asthma and Lung UK Annual Survey

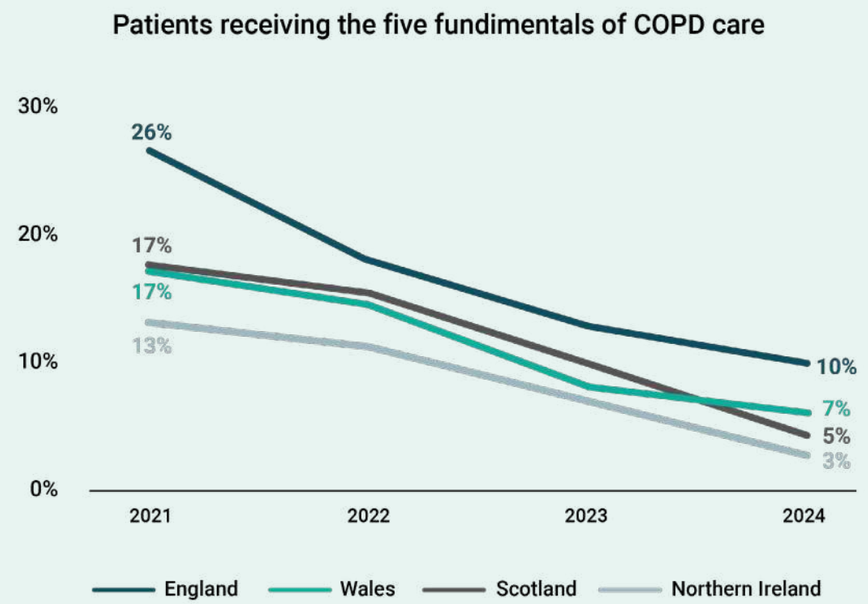
Asthma and Lung UK carry out an annual survey, 'Life with a lung condition', from which thousands of people with a lung condition across the UK share their experiences of care and living with a lung conditions. In 2024, the survey had over 12,000 responses and showed that only 21% of asthma patients in Wales received all of the recommended elements of basic asthma care. This has continuously decreased from 39% in 2019 and is 10% lower than the UK overall (Figure 29).

Figure 29. Percentage of asthma patients receiving basic asthma care levels in Wales and the UK from 2014 to 2024. Reproduced with permission from Asthma and Lung UK, 2024 (2).



Similarly, the percentage of patients receiving the five fundamentals of COPD care has steadily decreased from 2021 to 2024 across all home nations. In the 2024 survey, this percentage was 7% in Wales, higher than in Scotland and Northern Ireland, but lower than in England (Figure 30). Overall, there is no clear sense from the asthma and lung UK survey that Wales differs from the UK in that both have seen a general decline in respiratory care in recent years particularly following the COVID pandemic. It is interesting that this general decline in COPD care is not reflected in the survey work carried out in this report for people using the ICST toolkit apps. The surveys taken for people using the Apps shows a general increase in basic asthma care.

Figure 30. Percentage of COPD patients receiving the five fundamentals of COPD care in England, Wales, Scotland and Northern Ireland from 2021 to 2024. Reproduced with permission from Asthma and Lung UK, 2024 (2).



3.5.1.1.3 National Respiratory Audit Programme (NRAP) Data

COPD

The National Respiratory Audit Programme (NRAP) data highlights the importance of providing specialist respiratory care in COPD, which improves patient outcomes. Data shows that current access to specialist respiratory care for COPD is limited, with only 31% of services having a dedicated respiratory consultant on call, and 30% of services reporting no specialty triage of acute admissions to respiratory medicine. Improvements in tobacco dependence support, and the delivery of integrated respiratory care were also highlighted as key steps to improving COPD care (Royal College of Physicians, 2024).

Asthma

The NRAP organisational audit 2024 highlights the importance of improving access to biologic care for severe asthma, which would reduce the need for steroid treatment and improve patient outcomes and quality of life. The importance of providing access to respiratory specialist pharmacists was also highlighted, which would support the prescribing of asthma biologic therapy (Royal College of Physicians, 2024 (2))

Breathing Well Report

Data from the breathing well report 2024 highlighted inequalities in relation to respiratory health in England and Wales: It was shown that the highest proportion of individuals admitted to hospital with an exacerbation of COPD or asthma, and those assessed for pulmonary rehabilitation live in the most deprived quintile. This highlights the importance of addressing deprivation-related inequalities in respiratory care, with the report recommending local health boards to ensure that they have 100% service participation (Royal College of Physicians, 2024 (3)).

3.5.2 Impact of Patient-facing Apps on Respiratory Hospital Admissions

Health Board Level

Asthma and COPD-related hospital admissions were compared to the uptake of the apps in each health board to investigate any health board-wide impact of the apps. No significant relationship was found between the number of asthma-related admissions in each health board and the uptake of the Health Hub asthma apps in the health board (see figure 31). Additionally, no significant relationship was found between the number of COPD-related admissions in each health board and the uptake of the COPDhub app in the health board (see figure 32). A possible rationale for this is the fact that only between 5-7% of asthma or COPD patients are using the Healthhub apps across Wales. Therefore, there might not be enough patients using the apps to reflect significant changes in health board wide statistics. Unfortunately, due to data governance issues, there is no robust national data comparing app usage to actual hospital admissions. Other factors between health boards are likely to have a greater impact on asthma and COPD-related outcomes. To address this, the data were analysed at the GP practice level to investigate if there is a detectable difference in outcomes between practices with varying levels of Healthhub app adoption.

App uptake and hospital admissions: GP Practice Level

All Respiratory

The total number of respiratory-related ED attendances, hospital admissions and outpatient appointments for each GP practice in Wales were provided by DHCW for the period Feb 2020 to the end of April 2024.

Across the whole of Wales, there were a number of statistically significant correlations between overall app uptake and respiratory outcomes. The number of respiratory-related ED attendances per patient were significantly correlated with app uptake in 2021 ($R = 0.289$, $p < 0.001$), 2022 ($R = 0.373$, $p < 0.001$), 2023 ($R = 0.378$, $p < 0.001$) and 2024 ($R = 0.383$, $p < 0.001$), indicating the GP practices with the highest uptake of the app in terms of percentage of asthma and COPD patients using the app also had a higher number of respiratory-related ED attendances per patient registered at the practice. This was reflected by respiratory-related hospital admissions in 2021 ($R = 0.255$, $p < 0.001$), 2022 ($R = 0.242$, $p < 0.001$), 2023 ($R = 0.262$, $p < 0.001$) and 2024 ($R = 0.308$, $p < 0.001$). No significant relationship was found between the respiratory outpatient appointments per patient at a practice and overall uptake of the app amongst the asthma and COPD population.

However, as respiratory outcomes include outcomes for all patients at a GP practice, this may not be reflective of the asthma and COPD population i.e. the population that will potentially benefit from app use. Asthma and COPD-specific outcomes were analysed separately to determine any impact of app uptake on the asthma and COPD populations.

Figure 31. Comparison of asthma-related hospital admissions in 2022/2023 and Asthmahub/Asthmahub for Parents uptake in each health board.

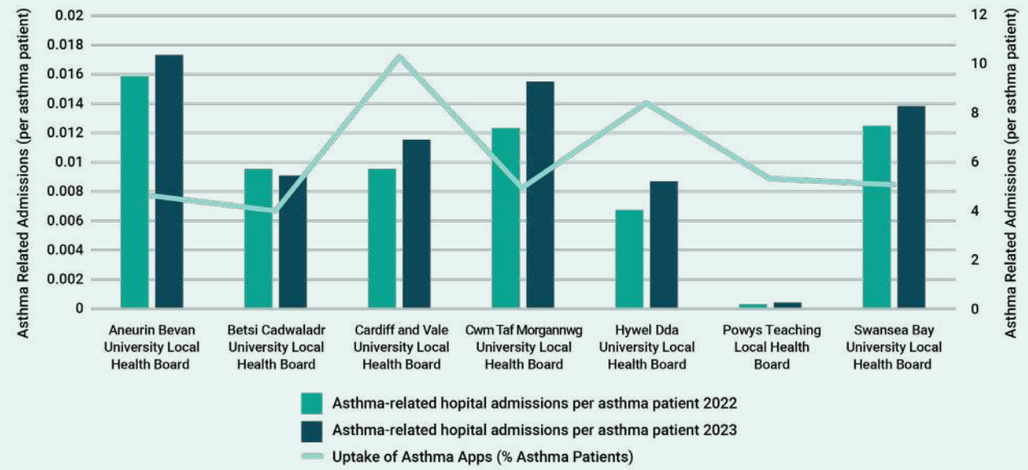
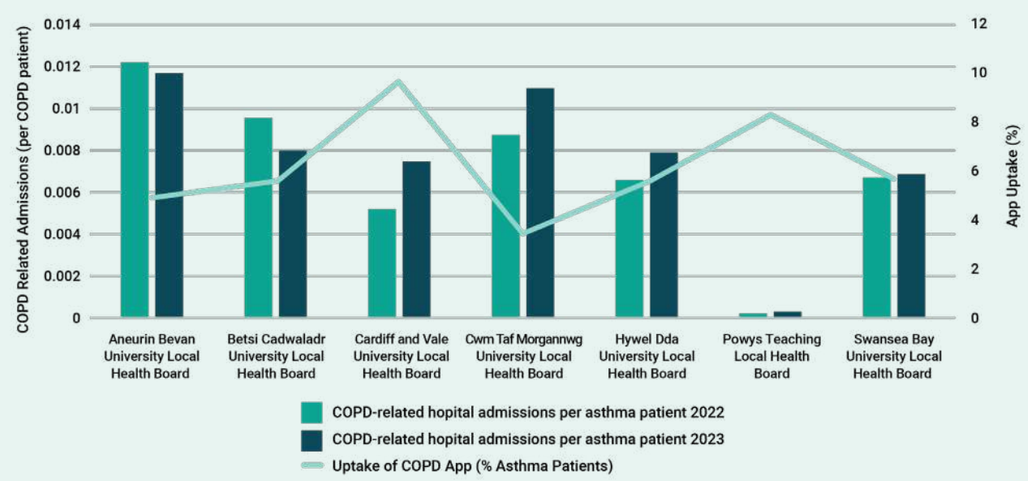


Figure 32. Comparison of COPD-related hospital admissions in 2022/2023 and COPDhub uptake in each health board.



Asthma
No significant correlation was found between the percentage of patients using the Asthmahub or Asthmahub for parents' app at a GP practice and the number of asthma-related hospital admissions per patient at that practice for 2021, 2021, 2022 or 2023 or 2024 across Wales. As uptake is not normally distributed, with the majority of GP practices having less than 10% adoption, small effects could go undetected through correlation analysis. To address this, the highest uptake practices were compared to the overall mean for hospital admissions.

As can be seen in table 10, the median number of hospital admissions related to asthma for the top adopting GP practices was not significantly different from the lowest adopting GP practices.

COPD
Significant negative correlations were observed between the percentage of COPD patients using the app at a practice and the number of hospital admissions, indicating GP practices with a larger percentage of patients using COPDhub had fewer COPD-related hospital admissions. When correcting for the number of COPD patients at a practice, significant negative correlations were observed in 2021 (R = -0.118, p = 0.022) and 2023 (R = -0.136, p = 0.010), indicating reduced COPD-related admissions were associated with increased uptake of COPDhub for these years.

As with asthma, the highest adopting practices were compared to the lowest to investigate any impact the app could have on COPD-related hospital admissions. As can be seen in table 11 more COPD-related hospital admissions were observed in the higher adopting practices for 2020, but fewer COPD-related hospital admissions were observed in these practices from 2021-23, however, this was not statistically significant. No statistically significant differences were found in deprivation for the highest and lowest adopting practices of COPDhub.

Table 10. Comparison of asthma-related hospital admissions from 2020 to 2024 in highest adopting practices in Wales of Asthmahub and Asthmahub, compared to the lowest adopting practices per asthma patient. MAPPPP = Mean Admissions Per Patient Per Practice. Note, 2024 data from Jan to April.

	n	WIMD	MAPPPP (2020)	MAPPPP (2021)	MAPPPP (2022)	MAPPPP (2023)	MAPPPP (2024)
Practices with >20% patients using app	10	1182 (632.3, 1419.5)	0.0089 (0.0056, 0.0252)	0.0081 (0.0044, 0.0091)	0.0096 (0.0079, 0.025)	0.0109 (0.0072, 0.0150)	0.0046 (0.0022, 0.0079)
Practices with <2% patients using app	91	682.3 (394.8, 1254.5)	0.0063 (0.0034, 0.0106)	0.0085 (0.0056, 0.0110)	0.0076 (0.0048, 0.0123)	0.0098 (0.0051, 0.0151)	0.0031 (0.0019, 0.0052)
Difference	81		+0.0026	-0.0004	+0.002	+0.0011	+0.0015
Significance	N/A	0.096	0.104	0.303	0.180	0.572	0.324

Table 11. Comparison of COPD-related hospital admissions from 2020 to 2024 in highest adopting practices in Wales of COPDhub, compared to the lowest adopting practices per COPD patient. MAPPPP = Mean Admissions Per Patient Per Practice. Note, 2024 data from Jan to April. Insufficient data was available for 2024.

	n	WIMD	MAPPPP (2020)	MAPPPP (2021)	MAPPPP (2022)	MAPPPP (2023)	MAPPPP (2024)
Practices with >20% patients using app	7	1184 (418, 1246)	0.0733 (0.0303, 0.1328)	0.0523 (0.0264, 0.1132)	0.0702 (0.0487, 0.2026)	0.0635 (0.0238, 0.0862)	N/A
Practices with <2% patients using app	75	623.5 (336.3, 1069)	0.0557 (0.0405, 0.0782)	0.0803 (0.0579, 0.1016)	0.0847 (0.0524, 0.1263)	0.0936 (0.0584, 0.1121)	0.0265 (0.0142, 0.0396)
Difference	68		+0.0176	-0.0280	-0.0145	-0.0301	N/A
Significance	N/A	0.257	0.702	0.208	0.959	0.092	N/A

3.5.3 Impact of the Respiratory Toolkit on Primary Care Outcomes

Scheduled and Unscheduled GP Appointments
GP practices were requested to provide data on scheduled and unscheduled appointments related to asthma and COPD. Data was only provided by 6 of the practices. Data from one practice was incomplete, leaving data from five practices usable. Although asthma and COPD-related unscheduled appointments per patient were higher in low adoption practices, this difference was not significant. However, the very low response rate and lack of data from GP practices limited the analysis that could be conducted.

Patient-reported GP Attendances (Asthmahub)
App users were given the opportunity to report GP attendances through the Health Hub apps, on a monthly basis. This data was provided by ICST for Asthmahub users that reported their attendances for at least 2 monthly periods from January 2022 to May 2024 (n = 404). The total reported GP attendances for each user were compared for the 12-month periods of Jan-Dec 2022 and Jan-Dec 2023. Significantly fewer GP attendances were reported by users in 2023 when compared to 2022. To assess if this could be due to users not reporting as frequently in 2023, the number of months where users provided their GP attendance data were compared for 2022 and 2023 (Table 13).

Table 12. Comparison of GP attendances reported by app users in 2022 and 2023. Significance assessed by Wilcoxon Signed Rank Test.

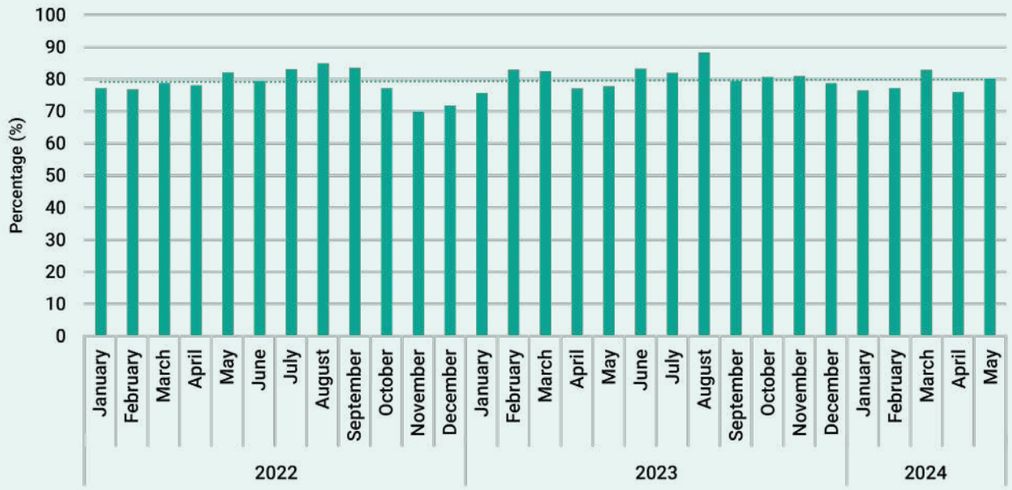
	2022	2023	Significance
Patient-reported GP attendances (median, IQR)	0 (0, 1)	0 (0, 1)	<0.001
Patient-reported GP attendance (mean ± SD)	1.16 ± 2.48	0.81 ± 2.71	N/A

Table 13. Comparison of the number of months for each period for which users provided GP attendance data.

	2022	2023	Significance
Number of months during period where GP attendances reported (median, IQR)	2 (1, 4)	1 (0, 3)	<0.001
Number of months during period where GP attendances reported (mean ± SD)	3.13 ± 2.92	2.39 ± 3.13	N/A

Users provided GP attendance data for significantly fewer months in 2023 when compared to 2022. This could contribute to the overall reduction in the user-reported GP attendances. It is important to determine if there is a bias towards reporting GP attendances or reporting no GP attendances amongst the population for any significant clinical impact to be conclusive. Throughout the period, the percentage of users reporting no GP attendances remained relatively consistent at around 80% (Figure 33).

Figure 33. The percentage of users reporting no GP attendances each month for the period Jan 2022 to May 2024.



3.6 Effect of the toolkit on inhaler use

3.6.1 National Picture

Nationally, around 3% of all greenhouse gas emissions generated by the NHS come from inhalers prescribed for respiratory conditions (NHS Business Services Authority., 2024). Metered Dose Inhalers (MDIs) account for most of the inhalers prescribed in the UK. MDIs are high in GWP meaning they have a higher carbon footprint than Dry Powder Inhalers (DPIs) and Soft Mist Inhalers (SMIs) (Respiratory Health Implementation Group., 2024). NHS Wales has set a target to reduce the proportion of high GWP inhalers to less than 20% by 2025 (NHS Wales, 2021).

The All-Wales Asthma Guidelines were updated to support the decarbonisation agenda in 2021 (Respiratory Health Implementation Group., 2024). It is now recommended in the guidelines that the default option for inhaler prescription is a DPI, unless the patient has a better technique, or prefers to use an MDI. Furthermore, the prescribing guideline states 'Wherever possible, choose a device with a low GWP rather than those with a high GWP' (Respiratory Health Implementation Group., 2024).

3.6.2 Comparison of Changing Inhaler Use Across The UK

When comparing changes at a population level in switching to low carbon footprint inhalers, other UK nations have shown little improvement. In contrast Wales is leading the way and is performing consistently better than England (Figure 34). There were financial incentivised projects in England and other approaches which have so far not made a significant impact. One of the key objectives of the ICST toolkit is supporting the All-Wales agenda around decarbonisation. It is believed that the ICST Toolkit has positively influenced the switch to low GWP inhalers, in part, due to the various guidelines and educational materials promoted through the apps.

The percentage of DPI and SMI use was provided by the All-Wales Therapeutics and Toxicology Centre (AWTTC) for each year from 2018 to 2024 at a GP practice level. Correlations were investigated between the uptake of ICST apps at a GP practice and the percentage of DPI and DMI inhalers for each year.

Figure 34. Comparison of DPI/SMI inhaler use as a percentage of the total prescribed inhalers in England and Wales (Data provided by AWTTC).

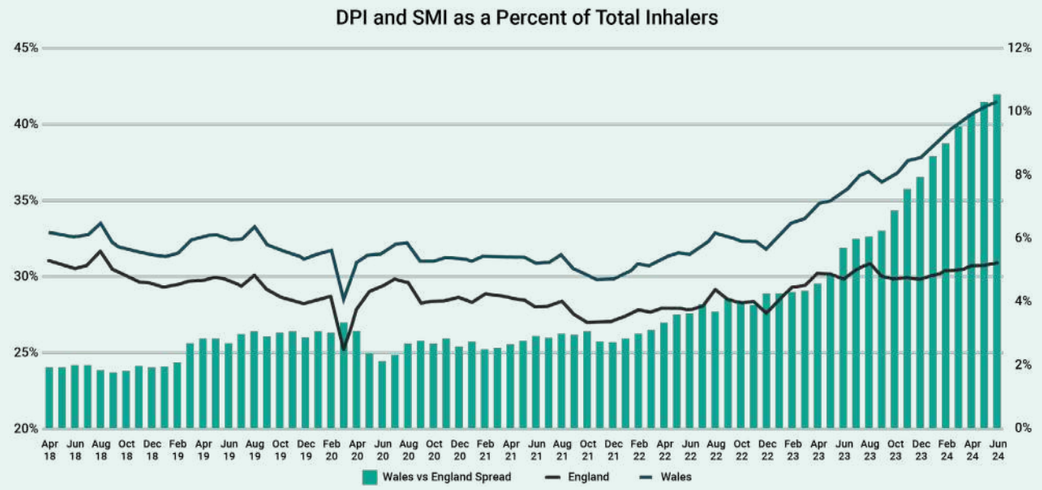


Table 14. Correlation between the present-day Health Hub app uptake and the prescription of DPI/SMI inhalers as a percentage of all inhalers prescribed from 2018 to 2024. *Significant at the 0.01 level.

		DPI and SMI % 2018	DPI and SMI % 2019	DPI and SMI % 2020	DPI and SMI % 2021	DPI and SMI % 2022	DPI and SMI % 2023	DPI and SMI % 2024
% Health Hub app uptake at GP practice	Pearson Correlation	0.073	0.112	0.160	0.181	0.288	0.367	0.372
	Significance n	0.152 382	0.029 382	0.002 382	<0.001* 381	<0.001* 377	<0.001* 370	<0.001* 364

As can be seen in table 14 correlations between DPI/SMI percentage as a total of all inhalers prescribed and the uptake of the Health Hub apps at a GP practice were significantly correlated from 2021 to 2024. Interestingly, correlations grew stronger each subsequent year, whereas there was no correlation in 2018 before the respiratory toolkit was implemented.

To further investigate this relationship, the top adopting practices were compared to the bottom adopting practices (Table 15). GP practices with a relatively high level of adoption of Health Hub apps (>20%) saw a significantly higher proportion of DPI/SMI inhaler prescriptions than GP practices that had a relatively low level of adoption of the Health Hub apps (<2%) for the years 2022 through to 2024, indicating the potential role of the ICST toolkit in driving the change from GWP to DPI/SMI inhaler use.

Table 15. Comparison of DPI/SMI % of total inhaler prescriptions for 'high' and 'low' adopting practices of the Health Hub apps. *Significant at the 0.01 level, independent samples t-test.

Year	Grouping Variable	N	DPI/SMI as a % of Inhaler Prescriptions	Significance (Two-sided p)
2018	Practices with >20% adoption	7	30.5 ± 10.3	
	Practices with <2% adoption	72	30.4 ± 7.7	0.983
2019	Practices with >20% adoption	7	32.0 ± 9.1	
	Practices with <2% adoption	72	30.0 ± 7.9	0.540
2020	Practices with >20% adoption	7	32.6 ± 9.1	
	Practices with <2% adoption	72	28.7 ± 7.9	0.225
2021	Practices with >20% adoption	7	31.9 ± 8.7	
	Practices with <2% adoption	72	28.1 ± 7.8	0.226
2022	Practices with >20% adoption	7	42.4 ± 7.1	
	Practices with <2% adoption	71	29.5 ± 7.6	<0.001*
2023	Practices with >20% adoption	7	55.0 ± 11.1	
	Practices with <2% adoption	69	34.3 ± 9.1	<0.001*
2024	Practices with >20% adoption	7	59.8 ± 12.2	
	Practices with <2% adoption	68	38.8 ± 10.3	<0.001*

3.6.3 Environmental Impact

Picture in Wales

The most commonly prescribed inhalers in Wales are the Ventolin Evohaler and the generic salbutamol MDI (Barry, S et al., 2022), each with a carbon footprint equivalent to 28kg of CO2 per inhaler. In comparison, DPIs typically have a carbon footprint of less than 1kg equivalent of CO2 per inhaler (National Institute for Health and Care Excellence., 2022).

The mean percentage of DPI/SMI use across Wales is currently 41.6% (SD 10.5), with the highest adopting practices of the Health Hub apps (>20%) exhibiting 59.8% (SD 12.2) DPI/SMI use.

To investigate the environmental impact of changing from high to low GWP inhaler use, carbon footprint data related to inhaler use were provided by AWTTC for each GP practice. The carbon footprint of inhalers dispensed on prescriptions issued by each GP practice were compared for the 'high' and 'low' adopting practices (Table 16). The carbon footprint of inhalers dispensed on prescriptions were significantly lower for high adopting practices of the Health Hub apps, for all years from 2018 to 2024 compared to low adopting practices of the Healthhub Apps.

Table 16. Comparison of the carbon footprint of inhalers dispensed on prescriptions for practices with >20% adoption of the Health Hub apps and practices with <2% adoption.

Year	Grouping Variable	N	Carbon Footprint (equivalent CO2Kg)	Significance
2018	Practices with >20% adoption	7	52,541 ± 22,064	
	Practices with <20% adoption	72	124,219 ± 66,075	<0.001
2019	Practices with >20% adoption	7	68,414 ± 30,555	
	Practices with <20% adoption	72	168,336 ± 93,151	<0.001
2020	Practices with >20% adoption	7	68,918 ± 34,650	
	Practices with <20% adoption	72	182,886 ± 104,330	<0.001
2021	Practices with >20% adoption	7	60,959 ± 31,754	
	Practices with <20% adoption	72	175,727 ± 101,836	<0.001
2022	Practices with >20% adoption	7	48,259 ± 27,422	
	Practices with <20% adoption	71	167,824 ± 102,116	<0.001
2023	Practices with >20% adoption	7	32,449 ± 18,971	
	Practices with <20% adoption	69	144,489 ± 90,187	<0.001
2024	Practices with >20% adoption	7	19,862 ± 13,644	
	Practices with <20% adoption	68	87,627 ± 58,991	0.004
2024 Est. full year	Practices with >20% adoption	7	29,794 ± 20,466	
	Practices with <20% adoption	72	124,139 ± 91,149	<0.001

To account for the varying number of patients at each practice, the carbon footprint data was standardised per 1000 patients (see Table 17). It was found that practices with low adoption rates of the Health Hub apps had a significantly higher carbon footprint for inhalers dispensed per 1000 patients (All Wales Therapeutics and Toxicology Centre, 2024).

Table 17. Comparison of the carbon footprint of inhalers dispensed on prescriptions per 1000 patients for practices with >20% adoption of the health hub apps vs practices with <2% adoption of the health hub apps. *Significant at the 0.001 level.

Year	Grouping Variable	N	Carbon footprint per 1000 patients (equivalent CO2kg)	Significance
2018	Practices with >20% adoption	7	1,133 ± 647	
	vPractices with <20% adoption	72	1,963 ± 543	<0.001*
2019	Practices with >20% adoption	7	1,081 ± 585	
	Practices with <20% adoption	72	1,965 ± 558	<0.001*
2020	Practices with >20% adoption	7	1,085 ± 643	
	Practices with <20% adoption	72	2,089 ± 588	<0.001*
2021	Practices with >20% adoption	7	966 ± 549	
	Practices with <20% adoption	72	1,968 ± 579	<0.001*
2022	Practices with >20% adoption	7	755 ± 444	
	Practices with <20% adoption	71	1,846 ± 600	<0.001*
2023	Practices with >20% adoption	7	487 ± 266	
	Practices with <20% adoption	69	1,547 ± 569	<0.001*
2024	Practices with >20% adoption	7	434 ± 234	
	Practices with <20% adoption	68	1,343 ± 524	<0.001*

Although both high adopting and low adopting practices managed to reduce their carbon footprint for inhalers dispensed, high adopting practices had a reduction of 57.0% whereas low adopting practices had a reduction of 21.2% per 1000 patients from 2018 to 2023 (most recent full year).

Across the whole of Wales, GP practices reduced their carbon footprint for inhalers dispensed from 1,726 ± 671 CO2kg equivalent in 2018 to 1,278 ± 517 CO2kg equivalent per 1000 patients in 2023 (26.0% reduction). The additional reduction in CO2 equivalent for high adopting practices, if achieved for the whole of Wales would equate to around 19,969,638 CO2kg equivalent per annum.

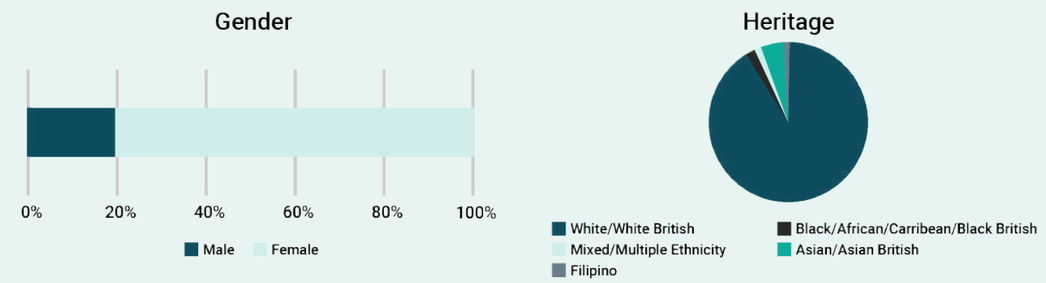
3.7 Impact on HealthCare Professionals

3.7.1 HCP Survey

The HCP survey (Appendix 12) was shared with respiratory professionals across Wales, through the WTS mailing list, as well as through the ICST users mailing list. Furthermore, a link to the survey was sent to the GP practices that had agreed to take part in the evaluation for completion by their staff.

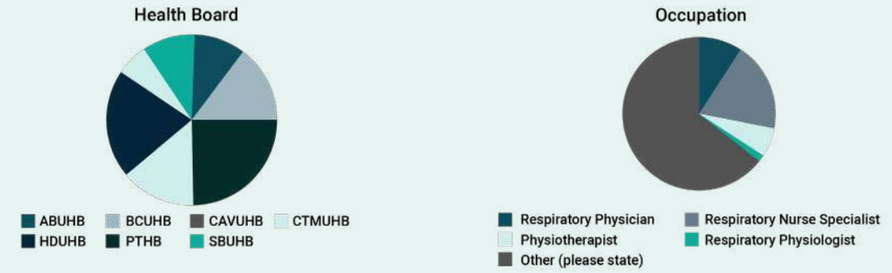
A total of 162 healthcare professionals (HCPs) participated in the survey, with 55 completing all sections. Partially completed surveys were included in the analysis when possible. The majority of respondents were female (110 women compared to 28 men), with a mean age of 48 years.

Figure 35. Gender and heritage of HCP survey respondents.



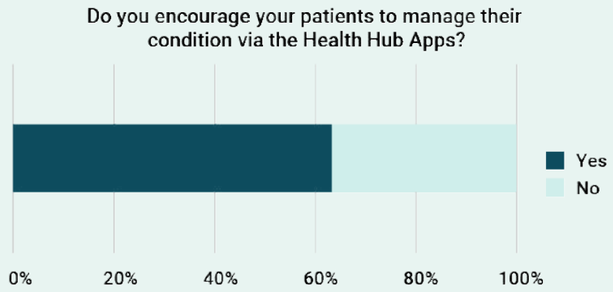
Respondents were distributed across Wales, with HCPs from all seven health boards participating in the survey (Figure 36). The most common response to the question "What best describes your role?" was "other," with the majority being practice nurses or general practitioners.

Figure 36. Survey respondents by health board and occupation.



When asked if they encouraged their patients to manage their condition via the Healthhub apps, the majority of respondents said 'Yes' (Figure 37). However, low uptake of the apps nationally mean it is unlikely that the majority of clinicians recommend the apps to their asthma and COPD patients.

Figure 37. Responses when asked 'Do you encourage your patients to manage their condition via the Health Hub Apps (COPDhub, Asthmahub and Asthmahub for Parents)?' (n = 125).



Clinical opinion of the apps was favourable, with the majority of respondents believing that the apps enabled them to get the most out of their consultations with patients and helped their patients to manage their condition more effectively (Figure 38).

Figure 38. Graph showing HCP responses when asked if they think the Health Hub apps enable them to get more out of their consultations with patients, and if they believe the apps help their patients to manage their condition more effectively (n = 74).

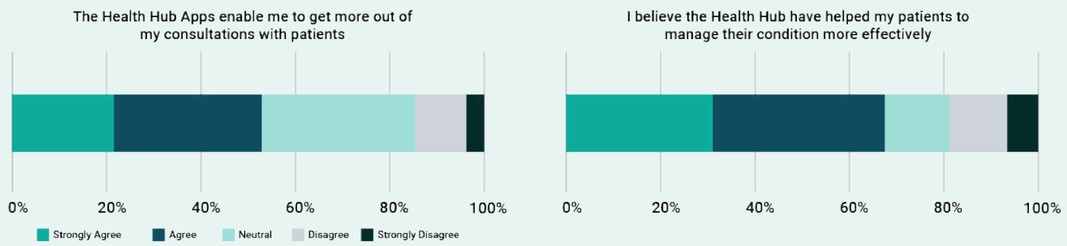
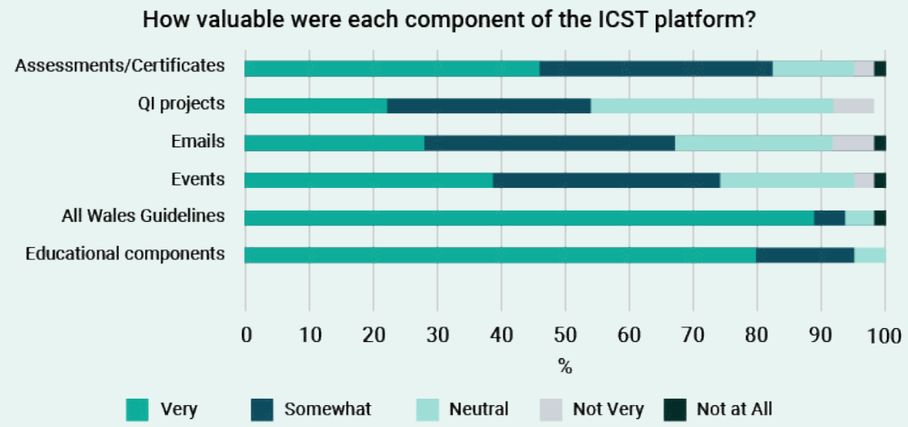


Figure 39. Responses by HCPs when asked how valuable they found each of the different components of the ICST platform.



When asked about the value of each platform component, staff responded very positively. More than 50% of the respondents rated every component as at least "somewhat" valuable. The All-Wales Guidelines and Educational components received particularly high levels, with nearly 90% of respondents finding the guidelines "very useful" and 80% finding the educational components "very useful."

3.7.2 HCP Interviews

Following the HCP survey, all healthcare professionals were invited to participate in interviews to provide deeper insights into their attitudes and experiences with the Healthhub apps. A total of 16 HCP interviews were conducted. For thematic analysis, these HCPs were categorised based on their area of healthcare: Primary Care (n=6) and Secondary Care (n=10).

3.7.2.1 Primary Care Final Themes:

The key themes for the HCPs working in primary care can be seen in figure 40. A more detailed explanation of the key themes can be seen below:

Theme 1. Standardising Clinical Practice
This theme highlights how the ICST platform fosters a unified approach to respiratory care by equipping healthcare professionals with standardised, evidence-based resources. The platform's guidelines and tools are pivotal in reducing variability in clinical practices across different settings and roles, ensuring that care remains consistent and of high quality. By streamlining the management of conditions like asthma and COPD, these resources enable practitioners to adhere to best practices with confidence.

Described as user-friendly and easily accessible, the platform's guidelines cater to both generalists and specialists, allowing quick reference and practical application during patient care. Their integration into training programs and everyday workflows further solidifies their role in maintaining uniform standards of care across Wales. This standardisation not only fosters trust among healthcare teams but also empowers practitioners to deliver consistent, reliable care, ultimately leading to improved patient outcomes.

Theme 2. Empowering Practitioners and Patients
The ICST platform enhances clinical confidence by providing healthcare professionals with structured resources such as e-learning modules and detailed guidelines. These tools are particularly valuable for practitioners who are new to respiratory care, ensuring they feel prepared to address complex cases and adjust treatments effectively. By supporting consistent application and facilitating relearning, the platform helps practitioners navigate challenges with assurance.

From the patient perspective, the platform's tools, including the Healthhub App and Wellness Dial, encourage self-management and active engagement in their care. Features like inhaler technique videos, action plans, and symptom monitoring empower patients to take control of their respiratory health, improving their ability to identify and respond to changes in their condition. This dual empowerment creates a collaborative dynamic between patients and practitioners, fostering clearer communication and supporting long-term respiratory health improvements.

"I think there's fantastic work being done by ICST and the platform, most of it is just brilliant and it's added value to all of us in Wales."

(Primary Care Pharmacist - Hwyl Dda UHB)

Theme 3. Accessible and User-Friendly Platform
The ICST platform is widely recognised for its accessibility and intuitive design, enabling healthcare professionals to quickly and seamlessly access critical resources. Features such as dedicated tabs for guidelines and structured e-learning modules make essential tools easily navigable, integrating smoothly into clinical workflows without causing significant disruptions. This design facilitates widespread adoption and enhances the platform's practicality for day-to-day use.

However, feedback from users indicates opportunities for improvement. Navigation challenges for first-time users, coupled with the need for clearer dashboards or site maps, highlight areas where usability could be enhanced. Addressing these gaps would ensure the platform remains inclusive and effective for all users. Despite these minor barriers, the platform's overall accessibility and intuitive design remain standout strengths, making it an invaluable resource in respiratory care.

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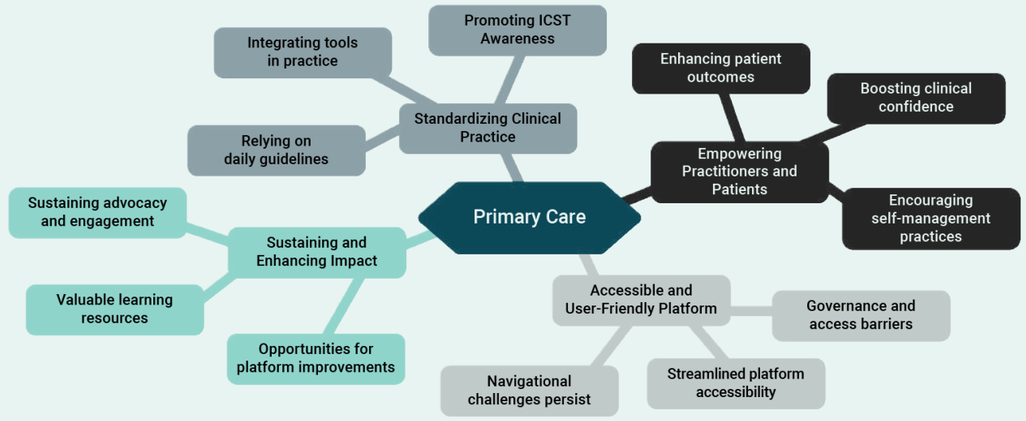
Theme 4. Sustaining and Enhancing Impact
This theme emphasises the importance of iterative development to ensure the ICST platform continues to meet the changing needs of healthcare professionals and patients. Participants consistently emphasised its immense value in delivering high-quality, centralised resources and expressed concern about the potential consequences of its absence. Maintaining the platform's availability is seen as essential for sustaining progress in respiratory care.

To remain relevant, recommendations include expanding educational content, increasing the frequency of webinars, and integrating patient-facing app data into healthcare systems. These enhancements would address existing barriers, adapt to emerging needs, and ensure the platform remains a key resource for practitioners and patients alike. By committing to continuous improvement, the ICST platform can reinforce its position as a vital tool for respiratory care in Wales and beyond.

Figure 40. Primary care employee's representation of final themes and associated sub-themes.



3.7.2.2 Secondary Care Final Themes:

The key themes for the HCP working in secondary care can be seen in figure 41. A more detailed explanation of the key themes can be seen below:

Theme 1. Empowering Excellence Through Training
The ICST platform plays a crucial role in the professional development of secondary care staff, embedding itself into the training and competency frameworks across teams. Secondary care professionals rely on ICST guidelines and modules to train both new and existing staff. For example, respiratory team leaders noted the regular use of ICST tools to maintain clinical standards, ensure staff confidence, and deliver consistent education.

The platform's structured learning modules, clear guidelines, and assessment tools help streamline training processes, allowing staff to focus on improving patient care rather than searching for disparate resources. Moreover, the ability to update training every 18 months ensures knowledge remains current and reflective of best practices. This routine use of ICST not only improves staff competence but also strengthens multidisciplinary team cohesion by providing a shared foundation of clinical knowledge.

"When we have staff that are new, we use the ICST online modules as part of our competencies and sign offs, as well as the practical elements and by doing so, many we supervise use that as part of their competency sheets before they're independently treating patients."

(Respiratory Clinical Lead - Powys UHB)

Theme 2. Consistency That Builds Confidence
This theme highlights the dual benefit of ICST in standardising care across secondary care settings and empowering both practitioners and patients. Secondary care practitioners frequently emphasised the importance of consistent clinical pathways, which ensure all team members—from consultants to nursing staff—provide unified care. This standardisation reduces discrepancies in patient treatment and promotes trust in the system, fostering improved clinical outcomes.

Simultaneously, ICST tools empower staff by reinforcing confidence in their prescribing and decision-making. Practitioners can confidently rely on evidence-based guidelines to adjust treatments, prescribe inhalers, and manage complex respiratory cases. On the patient side, ICST apps and self-management tools enable individuals to take greater responsibility for their health. Features like peak flow monitoring, symptom tracking, and digital action plans help patients better understand and manage their conditions, reducing dependence on clinical interventions and encouraging proactive care.

"It's hard to measure, but the guidelines give inexperienced clinicians confidence to step up or down treatment. It prompts referrals to smoking cessation or additional therapy, which benefits patients."

(Senior Respiratory CNS - Hwyl Dda UHB)

3. Bridging Barriers Through Accessibility
The ICST platform is widely praised for its intuitive layout and accessible design, making it easy for secondary care professionals to integrate it into their workflows. Features such as straightforward navigation, well-organized guidelines, and clear modules with certification options enable seamless use, even in high-pressure environments like clinics and hospitals. Staff appreciate the platform's ability to support quick decision-making without adding complexity to their day-to-day operations.

However, usability barriers persist. For instance, rural patients often lack compatible devices or technical literacy, limiting app adoption in specific demographics. Similarly, older patients and those unfamiliar with technology struggle to engage with digital tools, requiring additional support from healthcare professionals. In addition, secondary care staff have pointed out gaps in paediatric-focused content and integration challenges with NHS systems, which reduce the platform's overall utility for some patient groups. Addressing these issues through targeted improvements would enhance the platform's inclusivity and reach.

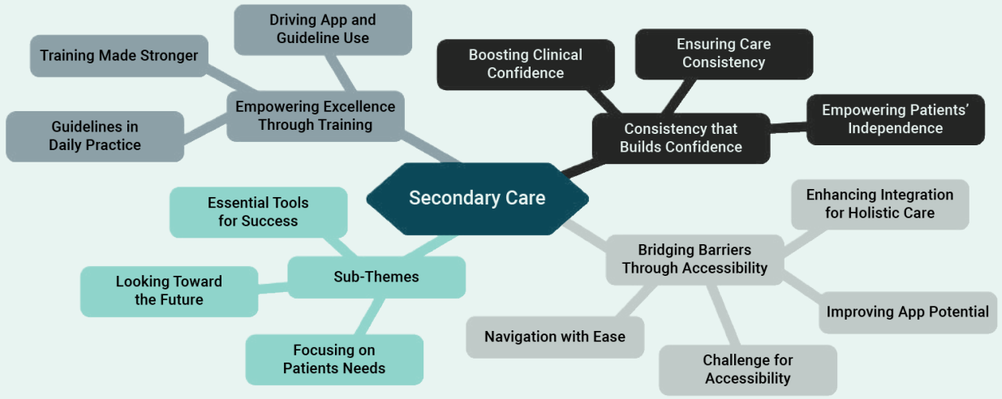
"I'm absolutely pro ICST. I really believe it's one of the most valuable things we've ever done across Wales. It supported us in education and for guiding healthcare professionals towards the platform."

(Senior Respiratory CNS - Hwyl Dda UHB)

4. Enhancing Integration for Holistic Care
This theme emphasises the need for ICST to evolve by integrating with broader healthcare systems and expanding its role in holistic care. Secondary care staff envision the platform as more than a standalone resource, suggesting it could integrate with NHS databases to streamline workflows, improve data accessibility, and enhance care continuity. For example, linking app data to hospital systems could allow practitioners to access real-time patient information, such as peak flows or inhaler usage, during consultations, enabling more personalized and informed care.

Additionally, staff recommended expanding the platform's scope to include underrepresented areas, such as biologics, paediatric pathways, and tools for community-based care. By addressing these gaps, ICST can better support the nuanced needs of secondary care. Practitioners also highlighted the platform's potential to support eco-conscious care, balancing green prescribing initiatives with practical solutions for patients. Through such integration and expansion, ICST can solidify its position as a comprehensive resource for modern respiratory care.

Figure 41. Secondary care employee's representation of final themes and associated sub-themes.



3.7.3 Commissioners Dashboard

Commissioners were contacted to discuss the usefulness of the information provided by ICST through various mediums in guiding their decisions. Four commissioners participated in semi-structured interviews. Of these, three had engaged with the materials, while one had not received the information via email or was unaware of the dashboard access. Those who received or engaged with the information were pleased with the frequency and medium of the reports. It was noted that a higher frequency of reporting was desirable early in the implementation process, but as implementation progressed, the need for frequent engagement with the data and reports decreased.

When asked how they preferred to receive reports, commissioners indicated a greater likelihood of engaging with the dashboard early in the implementation process, while preferring email reports later on. Regarding additional information to guide commissioning decisions, it was noted that linking the data provided by ICST to patient outcomes is challenging. However, this issue was attributed to a general lack of resources for collecting outcomes data, rather than a problem specific to ICST.

One commissioner did not engage with the materials, though it was unclear whether this was due to not receiving the information or being unaware of access to the ICST respiratory toolkit.

3.8 Usability Analysis of the ICST Respiratory Toolkit

A usability analysis was carried out as part of the Healthhub 2024 survey. The usability analysis was split between patient usage and HCP usage. The results of both can be seen below.

3.8.1 Patients Usability Analysis of the Healthhub Apps

The first part of this report provides an analysis of the aggregated data from all participants, encompassing users of all ICST Healthhub apps (COPDhub, Asthmahub for Parents, and Asthmahub). This initial analysis offers a general overview of the overall user experience and usability.

Subsequently, the data will be segmented and analysed based on the specific app used by participants. This segmented analysis will evaluate the individual performance of each app (COPDhub, Asthmahub for Parents, and Asthmahub) to highlight variations in user experience and usability across different contexts and user groups.

User Experience Questionnaire (UEQ) Data Analysis:
This section provides an in-depth analysis of user experience using the UEQ Short version, with responses from 419 participants (with some missing data points as shown in Table 1) evaluating the ICST HealthHub apps' usability and emotional impact. The UEQ analysis for patients using the ICST HealthHub apps assesses both Pragmatic and Hedonic qualities of user experience.

This section analyses the combined data from all users of the ICST HealthHub Apps to provide an overall view of user experience across the HealthHub Apps. Table 18 shows the mean scores per item, while Table 19 and Figure 42 illustrate the mean scores for each scale.

Table 18. UEQ mean, variance, and SD of both scales' items.

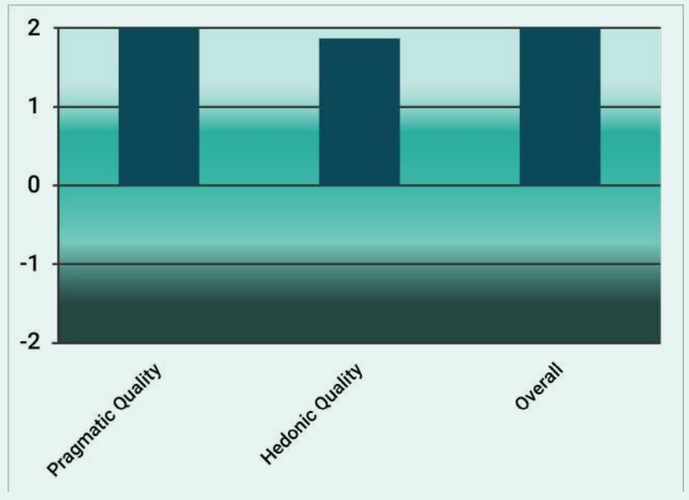
Item	Mean	Variance	Std. dev.	No.	Negative	Positive	Scale
1	1.3	2.7	1.6	417	obstructive	supportive	Pragmatic Quality
2	1.3	3.0	1.7	417	complicated	easy	Pragmatic Quality
3	0.9	3.3	1.8	414	inefficient	efficient	Pragmatic Quality
4	1.1	3.5	1.9	415	confusing	clear	Pragmatic Quality
5	0.2	2.8	1.7	419	boring	exciting	Hedonic Quality
6	0.7	3.1	1.8	417	not interesting	interesting	Hedonic Quality
7	0.7	2.1	1.5	416	conventional	inventive	Hedonic Quality
8	0.5	2.3	1.5	411	usual	leading edge	Hedonic Quality

The Pragmatic Quality score of 1.16 suggests that patients found the apps adequately functional and usable, while the Hedonic Quality score of 0.48 points to a lower level of engagement or emotional connection with the apps. This may reflect a need for features or design elements that enhance user enjoyment and appeal.

Table 19. UEQ Scales Mean Scores.

Short UEQ Scales	
Pragmatic Quality	1.160
Hedonic Quality	0.483
Overall	0.814

Figure 42. UEQ Scales Mean Scores.



These scores place the apps in the "Below Average" category relative to the benchmark data from over 21,000 users across various product types (e.g., business software, websites, and social networks). Specifically, approximately 50% of the benchmarked products scored better than the ICST Healthhub apps, while only 25% scored worse.

Two Figures (43 & 44) were generated to illustrate these benchmarks: one showing scale scores by category, and another showing scale scores with confidence intervals for added precision.

Figure 43. UEQ Scale Scores by Benchmark Category.

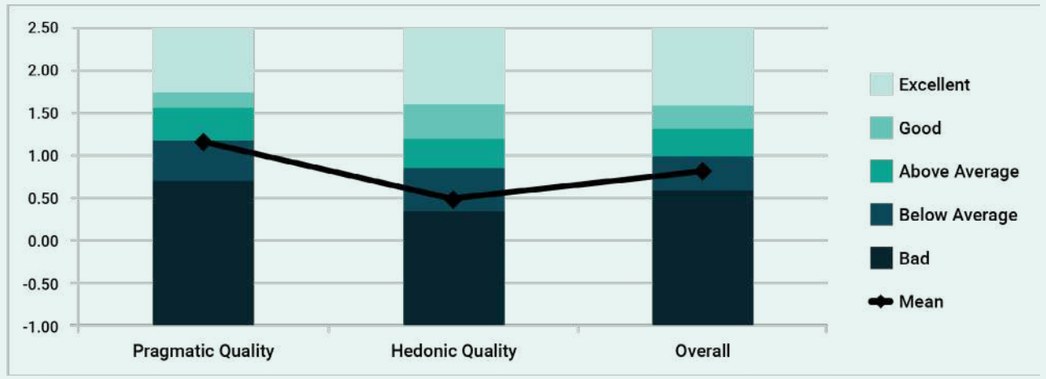
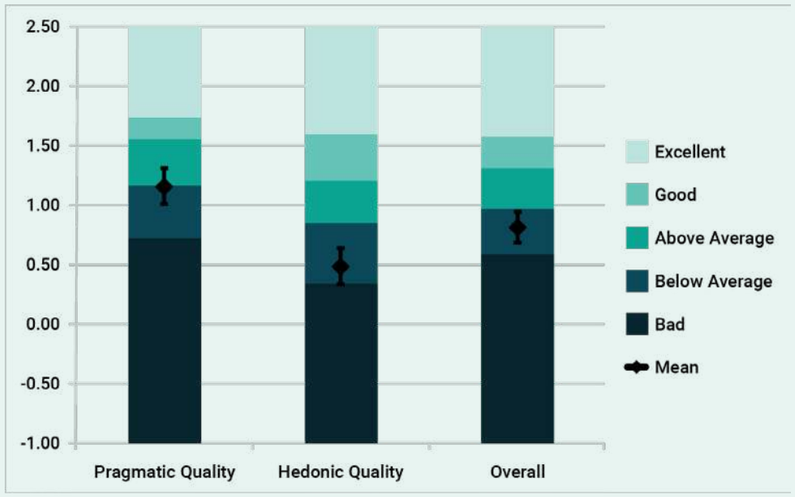


Figure 44. UEQ Scale Scores by Benchmark Category with the Confidence Intervals of the Scale Scores.



The 95% confidence intervals for the scales support the precision of these estimates, with smaller confidence intervals reflecting reliable user opinions (see Table 20).

Table 20. UEQ Confidence Intervals per Scale.

Confidence intervals (p=0.05) per scale						
Scale	Mean	Std. dev.	N	Confidence	Confidence Interval	
Pragmatic Quality	1.160	419	1.6	0.148	1.011	1.308
Hedonic Quality	0.483	419	1.7	0.134	0.349	0.618
Overall	0.814	419	1.8	0.130	0.685	0.944

As shown in Table 21, the internal consistency of the scales, indicated by Cronbach's Alpha values, demonstrates reliability in patient responses (Pragmatic Quality: 0.88, Hedonic Quality: 0.89). These alpha values exceed the threshold of 0.7, reinforcing the internal cohesion of each scale's items and suggesting consistent user interpretation.

Table 21. UEQ Cronbach's Alpha per Scale.

Pragmatic Quality		Hedonic Quality	
Alpha	0.88	Alpha	0.89

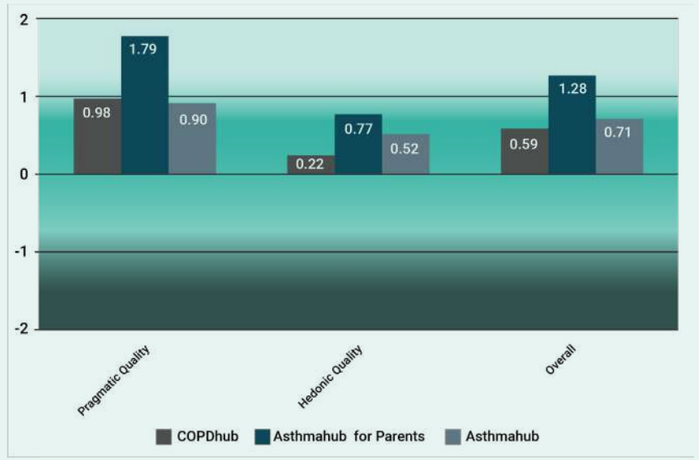
In summary, while the ICST Healthhub apps achieves a functional level of usability, it falls below average when compared to the benchmark data. This result indicates areas for improvement, particularly in enhancing the apps' engagement and emotional impact for patients.

The following section breaks down the data by app (COPDhub, Asthmahub for Parents, and Asthmahub) to identify app-specific insights and variations in user experience. Data where participants selected more than one app were excluded from this analysis. As shown in Table 22 and Figure 45 COPDhub demonstrated moderate usability, as indicated by its Pragmatic Quality score, but its low Hedonic Quality score suggests limited emotional engagement. The Asthmahub for Parents app scored the highest across all dimensions. Its Pragmatic Quality indicates strong usability, and its Hedonic Quality reflects better engagement compared to the other apps. While the Pragmatic Quality score for the Asthmahub app reflects good usability, the moderate Hedonic Quality suggests room for improvement in enhancing user engagement.

Table 22. UEQ Scales Mean Scores per App.

Short UEQ Scales	COPDhub	Asthmahub for Parents	Asthmahub
Pragmatic Quality	0.98	1.79	0.90
Hedonic Quality	0.22	0.77	0.52
Overall	0.59	1.28	0.71

Figure 45. UEQ Scales Mean Scores per App.



Across all three apps, Pragmatic Quality consistently outperforms Hedonic Quality, indicating that while users find the apps functional, they lack strong emotional engagement.

The internal consistency of the scales, indicated by Cronbach's Alpha values, demonstrates reliability in patient responses for both the Asthmahub for Parents and COPDhub (Pragmatic Quality: 0.96; 0.87, Hedonic Quality: 0.88; 0.88 respectively). These alpha values exceed the threshold of 0.7, reinforcing the internal cohesion of each scale's items and suggesting consistent user interpretation. However, the Cronbach's Alpha values for the Asthmahub (Pragmatic Quality: 0.03, Hedonic Quality: 0.56) were very low. These results should be interpreted with caution, particularly for the Asthmahub, as the low Cronbach's Alpha values indicate potential inconsistencies in how participants interpreted some scale items.

Notably, as shown in Figure 46 and 47, the Asthmahub for Parents app demonstrates the best balance between usability and engagement, approaching the "Good" usability benchmark, while COPDhub and Asthmahub remain closer to the "Below Average" category.

Figure 46. UEQ Scale Scores by Benchmark Category per App
(Blue: Asthmahub for Parent [N=12]; Black: Asthmahub [N=13]; and Green: COPDhub [N=101]).

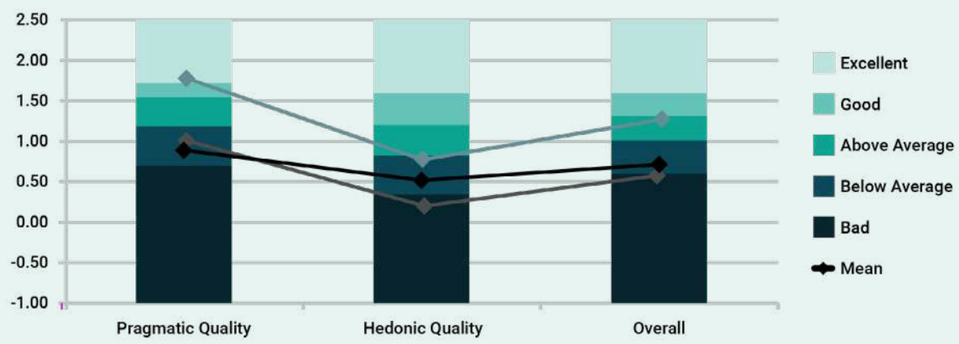
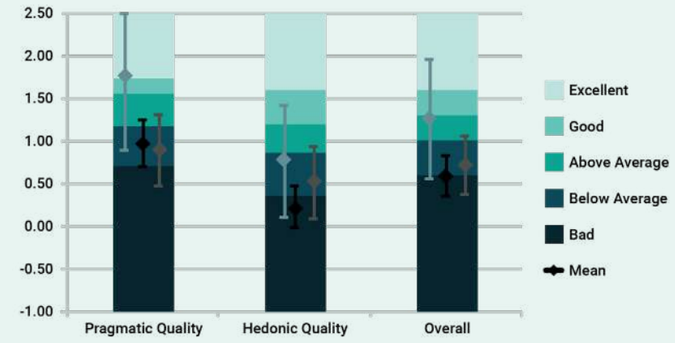


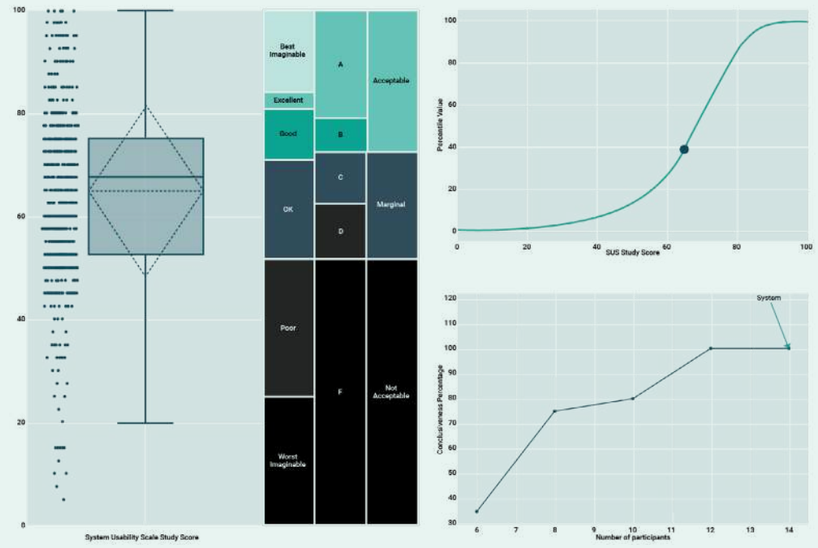
Figure 47. UEQ Scale Scores by Benchmark Category with the Confidence Intervals of the Scale Scores per App
(Blue: Asthmahub for Parents [N=12]; Black: COPDhub [N=101]; and Green: Asthmahub [N=13]).



System Usability Scale (SUS) Data Analysis:
This section provides an in-depth analysis of the System Usability Scale (SUS) scores from 606 participants. The SUS was administered to assess the overall usability of the ICST Healthhub apps. This section analyses the combined data from all users of the ICST Healthhub apps to provide an overall view of usability across apps.

The analysis of the SUS scores for patients using the apps provides valuable insights into the usability perception among participants. The mean SUS score of 64.74, with a standard deviation of 16.65, positions the app within the "OK" usability category. This score falls below the SUS benchmark average of 68. The median score of 67.5 aligns closely with the mean, suggesting a balanced representation of user sentiment. However, with a quartile distribution showing the first quartile (Q1) at 52.5 and the third quartile (Q3) at 75, there is notable variability in user experiences, with some finding the app highly usable while others encounter usability challenges. This variability suggests potential areas for improvement.

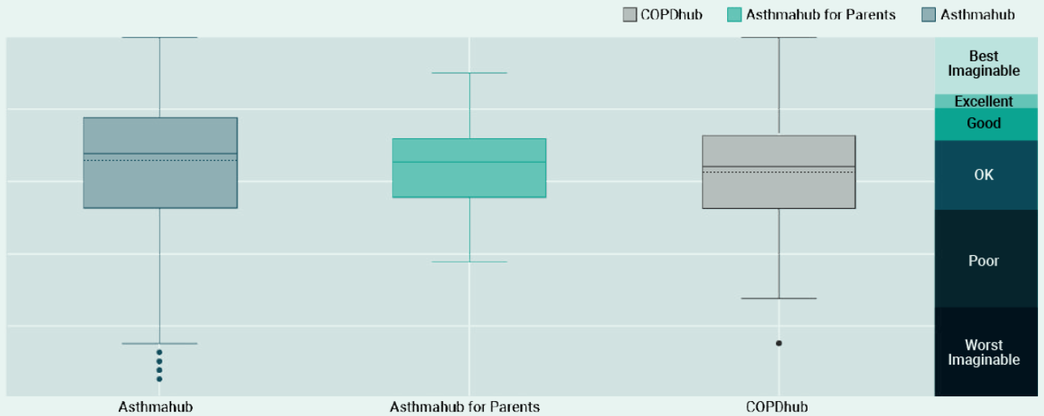
Figure 48. SUS Scores analysis.



The percentile curve further contextualises the SUS score, showing that it falls in the lower half of the benchmarked scores. In addition, the high level of conclusiveness, as shown in the reliability graph (12), indicates that the current sample size provides a stable and reliable representation of patient experiences with the app. This suggests confidence in the results, although future comparisons within a more specific digital health benchmark would provide a clearer assessment of the app's usability relative to similar healthcare applications.

The following section breaks down the data by app (COPDhub, Asthmahub for Parents, and Asthmahub) to assess their level of usability (See Figure 49). Data where participants selected more than one app were excluded from this analysis too.

Figure 49. SUS Scores analysis per App
(Asthmahub [N=409], Asthmahub for Parents [N=19], and COPDhub [N=152])



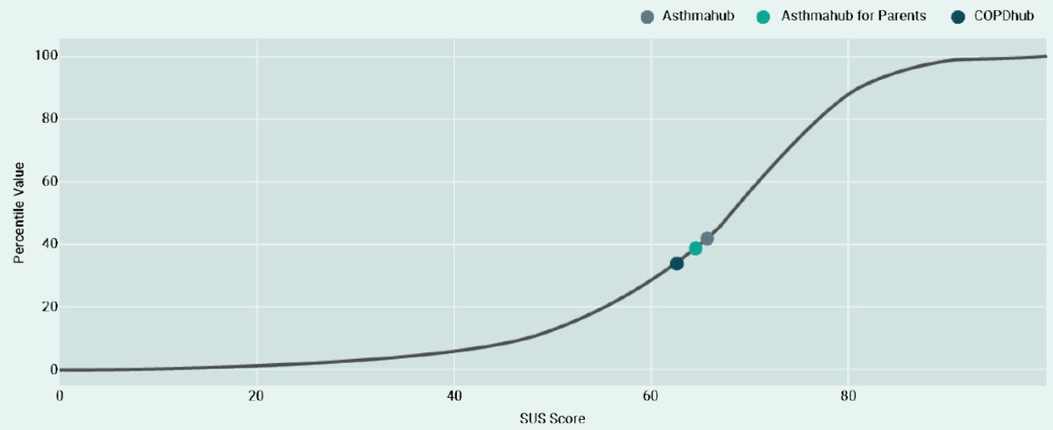
The SUS scores for Asthmahub show a mean of 65.53 and a median of 67.5, placing it within the "OK" usability category. The quartile distribution indicates variability, with the first quartile (Q1) at 52.5 and the third quartile (Q3) at 77.5. Several outliers on the lower end, as indicated by scores below 20, reflect challenges faced by certain users, potentially due to usability barriers. However, the upper quartile scores suggest that many users still found the app functional and intuitive.

The SUS scores for Asthmahub for Parents show a mean of 64.61 and a median of 65, also placing it within the "OK" usability category. The scores exhibit a narrower interquartile range compared to Asthmahub, with Q1 at 55.63 and Q3 at 71.88. This tighter range indicates a more consistent user experience, with fewer extreme outliers. The results suggest that the app provides a reasonably intuitive experience for most users, but it does not reach the "Good" usability threshold.

The SUS scores for COPDhub reveal a mean of 62.63 and a median of 63.75, also falling within the "OK" usability category. The first quartile (Q1) is at 52.5, and the third quartile (Q3) is at 72.5, indicating a wide distribution of scores. While the upper quartile scores approach the "Good" range, the presence of lower scores suggests that certain user groups face usability challenges.

The SUS percentile curve as shown in Figure 50 illustrates the relative position of each app's usability score compared to a broader dataset of SUS benchmarks. These results reinforce the need for targeted refinements and improvments that could push the apps toward the higher usability thresholds.

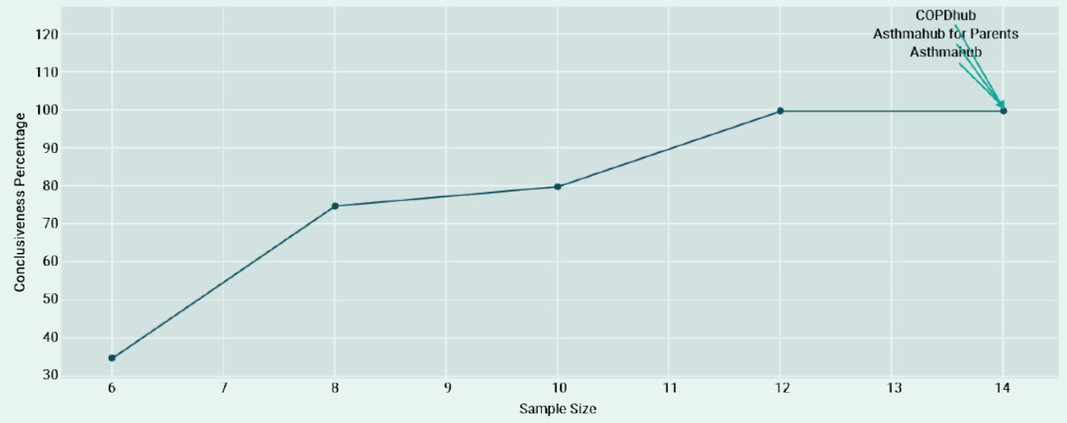
Figure 50. Percentile Value of SUS scores per App.



The conclusiveness graph (See Figure 51) illustrates the relationship between sample size and the conclusiveness percentage for the SUS analysis of the three apps, Asthmahub, Asthmahub for Parents, and COPDhub.

The conclusiveness percentage reaches approximately 100%, indicating that the findings are stable and additional participants are unlikely to significantly alter the results.

Figure 51. Conclusiveness Percentage of the SUS scores per App.



This final analysis summarises 229 participant responses regarding the most useful features of the apps (Asthmahub, Asthmahub for Parents, and COPDhub) and suggestions for improvement. Quotes are included, referenced by participant ID and app name.

Most Useful Features Identified

1. Asthmahub
Participants frequently highlighted the peak flow recording feature as particularly useful. Additional mentions included educational resources and tools for tracking asthma-related data:

- "*The ability to record readings from peak flow tests.*" – *P68, Asthmahub*
- *"Recording my peak flow and the advice given when it is too low."* – *P352, Asthmahub*
- *"Educational videos and tracking my asthma over time."* – *P318, Asthmahub*

Some participants valued the app for providing general asthma management support:

- *"Helps me keep informed about my condition."* – *P362, Asthmahub*
- *"Information about managing my asthma."* – *P54, Asthmahub*

Others found the reminders and monthly tracking features beneficial:

- *"Monthly tracking, found it easy to find the video tutorials."* – *P305, Asthmahub*
- *"Reminders to use it more regularly."* – *P378, Asthmahub*

2. Asthmahub for Parents
In Asthmahub for parents, participants also found value in the peak flow recording feature to monitor progress:

- *"The traffic light system of the users' peak flow."* – *P230, Asthmahub for Parents*
- *"Peak flow and questionnaire."* – *P314, Asthmahub for Parents*

3. COPDhub
In COPDhub, participants found value in symptom tracking, educational topics, and tools to monitor progress:

- *"The articles and being able to keep records of all things related to my journey with COPD."* – *P528, COPDhub*
- *"The advice to take if conditions worsen."* – *P138, COPDhub*
- *"Tracking progress with a calendar."* – *P313, COPDhub*
- *The long-term summary to see how my health looks over the year."* – *P476, COPDhub*
- *"Educational topics on COPD."* – *P301, COPDhub*

For some, ease of use and access to information were key highlights:

- *"Everything in the same place and very informative."* – *P81, COPDhub*
- *"Easy to use for information."* – *P368, COPDhub*

Others found the advice provided action oriented:

- *"The advice to take if conditions worsen."* – *P138, COPDhub*
- *"It advises you on a course of action to take."* – *P518, COPDhub*

Suggestions for Improvement

1. Asthmahub
Several participants suggested improving data accessibility and app integration:

- *"Enable it so the data can be transferred directly to the hospital/GP for my records."* – *P272, Asthmahub*
- *"It needs to automatically upload info to medical records."* – *P446, Asthmahub*
- *"Integrate with Apple Health for easier tracking."* – *P494, Asthmahub*

Others mentioned enhancing the usability and user interface:

- *"Clicking between week, month, year takes too long for the screen to change."* – *P96, Asthmahub*
- *"Improve the wellness dial; it's clunky to get the right zone."* – *P413, Asthmahub*

A subset of participants expressed technical difficulties:

- *"I can't use the app anymore; it will not let me log in since I bought a new phone."* – *P442, Asthmahub*
- *"The app kept going offline, and I just gave up."* – *P93, Asthmahub*

2. Asthmahub for Parents
Several participants suggested improving data accessibility and app integration:

- *"Questions need to be more intuitive, i.e., not so prescribed."* – *P314, Asthmahub for Parents*
- *"Make the app more user-friendly for parents."* – *P436, Asthmahub for Parents*

Others mentioned enhancing the usability and user interface.

3. COPDhub
Participants noted the need for improved navigation and customisation:

- *"Easier navigation; there are features I know are in the app but I can't find them when I want to."* – *P476, COPDhub*
- *"Allow personalisation to cater to different stages of COPD."* – *P287, COPDhub*

Some also suggested adding reminders and notifications:

- *"Reminder notification to complete/enter data in the app."* – *P472, COPDhub*

A new feature was suggested:

- *"Include blood oxygen levels (%spO2)."* – *P521, COPDhub*

Additionally, some made comments about the general usability of the app:

- *"Make it usable, please."* – *P322, COPDhub*
- *"Keep it simple as people who are having an episode need to use it clearly and quickly."* – *P518, COPDhub*

In summary, the participants' responses reveal that the apps provide valuable features, such as peak flow monitoring, educational content, and actionable advice. However, recurring themes of improvement include navigation, integration with other systems (e.g., Apple Health or GP records), and addressing usability issues for less tech-savvy users. Tailoring features to specific user needs and enhancing technical stability can significantly improve the user experience.

3.8.1.1 Conclusion: Healthhub Usability for Patients

The analysis of the ICST Healthhub apps using the UEQ and SUS scales highlights a generally functional but moderately engaging user experience for patients. The average UEQ scores place the apps below the benchmark average, suggesting that while they meet basic usability needs, there is room for improvement, particularly in enhancing user engagement and emotional impact. The Pragmatic Quality score of 1.16 reflects adequate usability, while the Hedonic Quality score of 0.48 underscores the potential to improve user satisfaction by adding more engaging or appealing features.

Across all apps, Pragmatic Quality scores outperform Hedonic Quality, indicating that while users generally find the apps functional, they lack significant emotional or engaging elements. Asthmahub for Parents clearly outperforms the other apps, achieving scores that approach "Good" usability benchmarks, whereas COPDhub and Asthmahub fall closer to "Below Average". These results should be treated with caution due to small sample size.

The SUS results further indicate moderate usability, with a mean score of 64.74, which falls into the "Marginal" acceptability category. This means that while some patients found the Healthhub apps easy to use, others encountered usability challenges.

The SUS analysis across the apps shows that all three apps achieve usability in the "OK" range, with Asthmahub for Parents demonstrating a more consistent user experience and fewer extreme scores. Asthmahub shows the most variability, with a broader range of scores and lower outliers, suggesting that some users may find the app less intuitive. COPDhub similarly demonstrates variability, with some users rating it highly usable while others report challenges. The high conclusiveness percentage confirms the robustness of these findings.

The content analysis regarding most useful features and suggestions for improvements reveals that while users find the apps beneficial for tracking and managing their health conditions, there are consistent suggestions for improving usability, technical performance, and integration

with other platforms. Enhancing the apps' user interfaces, resolving technical issues, and increasing personalisation could address these concerns and improve user satisfaction.

These findings highlight the need for targeted improvements to enhance usability and support user groups facing barriers. Across all apps, refinements in design and workflows could help elevate usability scores to the "Good" or "Excellent" categories.

To elevate the app's usability and emotional appeal, targeted improvements could focus on enhancing engagement and providing support features that simplify the experience for new or less technical users. In addition, future assessments would benefit from a more targeted benchmark within the digital health industry to provide a clearer comparison of the app's usability relative to similar healthcare applications.

3.8.2 HCP User Experience Questionnaire (UEQ) Data Analysis

This section provides an in-depth analysis of user experience using the UEQ Short version, with responses from 55 HCP evaluating the All-Wales ICST platform's usability and emotional impact. Participants rated each item on a 7-point Likert scale, ranging from -3 (fully agree with negative term) to +3 (fully agree with positive term). The UEQ generates a numerical score for each scale (Pragmatic & Hedonic Qualities), along with an overall UX score that can be compared to a benchmark database of other products.

In this evaluation, the data analysis revealed high average scores across UEQ dimensions, indicating a generally positive user experience. Table 23 shows the mean scores per item, while Table 24 and Figure 52 illustrate the mean scores for each scale.

Table 23. UEQ mean, variance, and SD of both scales' items.

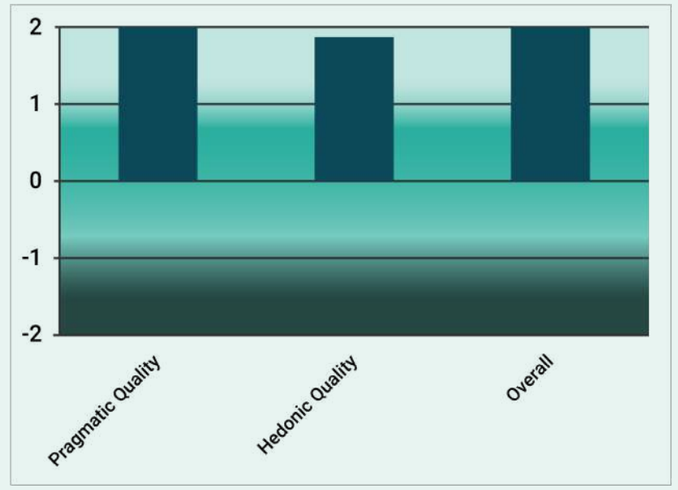
Item	Mean	Variance	Std. dev.	No.	Negative	Positive	Scale
1	2.4	0.8	0.9	55	obstructive	supportive	Pragmatic Quality
2	2.0	1.1	1.1	55	complicated	easy	Pragmatic Quality
3	2.1	1.1	1.0	55	inefficient	efficient	Pragmatic Quality
4	2.1	1.5	1.2	55	confusing	clear	Pragmatic Quality
5	1.8	1.2	1.1	55	boring	exciting	Hedonic Quality
6	2.2	1.0	1.0	55	not interesting	interesting	Hedonic Quality
7	1.6	2.1	1.5	55	conventional	inventive	Hedonic Quality
8	1.9	1.1	1.0	55	usual	leading edge	Hedonic Quality

While the scale ranges from -3 to +3, as Schrepp (2023) explains, scores in practical applications usually fall within a narrower range. This is due to averaging across users with varying opinions and response tendencies. For example, many users avoid extreme responses, making scores above +2 or below -2 rare. Therefore, a score of +1.5, though moderate on the full scale, represents a strong positive rating.

Table 24. UEQ Scales Mean Scores.

Short UEQ Scales	
Pragmatic Quality	2.159
Hedonic Quality	1.882
Overall	2.020

Figure 52. UEQ Scales Mean Scores.



The Pragmatic Quality mean score of 2.159 reflects a highly positive perception of usability, while the Hedonic Quality mean score of 1.882 suggests positive but slightly lower engagement levels compared to usability. These strong scores are supported by confidence intervals, providing statistical precision (see Table 25).

Table 25. UEQ Confidence Intervals per Scale.

Confidence intervals (p=0.05) per scale						
Scale	Mean	Std. dev.	N	Confidence	Confidence Interval	
Pragmatic Quality	2.159	0.886	55	0.234	1.925	2.393
Hedonic Quality	1.882	0.962	55	0.254	1.628	2.136
Overall	2.020	0.872	55	0.230	1.790	2.251

As shown in Table 26, an analysis of internal consistency using Cronbach's Alpha indicates reliable measurements for each scale:

Table 26. UEQ Chronbach's Alpha per Scale.

Pragmatic Quality		Hedonic Quality	
Alpha	0.87	Alpha	0.86

With alpha values above the standard threshold of 0.7, these results demonstrate strong internal consistency and reliable responses for each quality dimension. The high Cronbach's Alpha values suggest that items within each scale are well-correlated and consistently interpreted by users.

The All-Wales ICST platform was benchmarked against UEQ dataset of over 21,000 users across 468 studies covering various product types (e.g., business software, web pages, and social networks). This benchmark data, provided by UEQ developers, includes products that are not necessarily similar or direct competitors, offering a broad context rather than a precise industry comparison. Due to limited data for the short version, these benchmarks are based on the full UEQ, providing a rough approximation for short UEQ scores. Benchmark categories are defined as follows (Schrepp, Thomaschewski, & Hinderks, 2017):

- *Excellent:* In the range of the 10% best results.
- *Good:* 10% of the results in the benchmark data set are better and 75% of the results are worse.
- *Above average:* 25% of the results in the benchmark are better than the result for the evaluated product, 50% of the results are worse.
- *Below average:* 50% of the results in the benchmark are better than the result for the evaluated product, 25% of the results are worse.
- *Bad:* In the range of the 25% worst results.

Two Figures (53 & 54) were generated to illustrate these benchmarks: one showing scale scores by category, and another showing scale scores with confidence intervals for added precision.

Figure 53. UEQ Scale Scores by Benchmark Category.

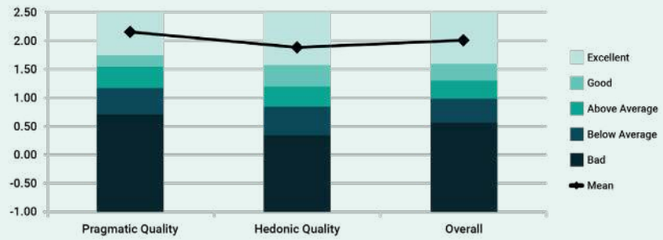


Figure 54. UEQ Scale Scores by Benchmark Category with the Confidence Intervals of the Scale Scores.

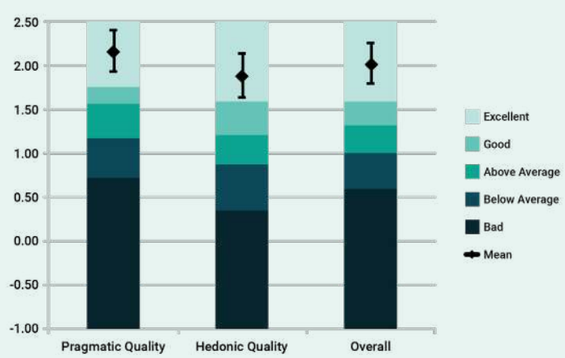


Table 27 shows that the platform's scores in both the pragmatic and hedonic scales rank within the top 10%, indicating excellent UX relative to a wide array of products, including business software, social networks, and web services.

Table 27. UEQ Scale Scores in comparison to Benchmark.

Scale	Mean	Comparisson to benchmark	Interpretation
Pragmatic Quality	2.159	Excellent	In the range of the 10% best results
Hedonic Quality	1.882	Excellent	In the range of the 10% best results
Overall	2.02	Excellent	In the range of the 10% best results

System Usability Scale (SUS) Data Analysis:
This section provides an in-depth analysis of the System Usability Scale (SUS) scores from 59 participants. The SUS was administered to assess the overall usability of the All-Wales ICST platform. The SUS score provides a reliable measure of perceived usability, with scores ranging from 0 to 100, where higher scores indicate better usability. The benchmark interpretation for SUS scores is as follows:

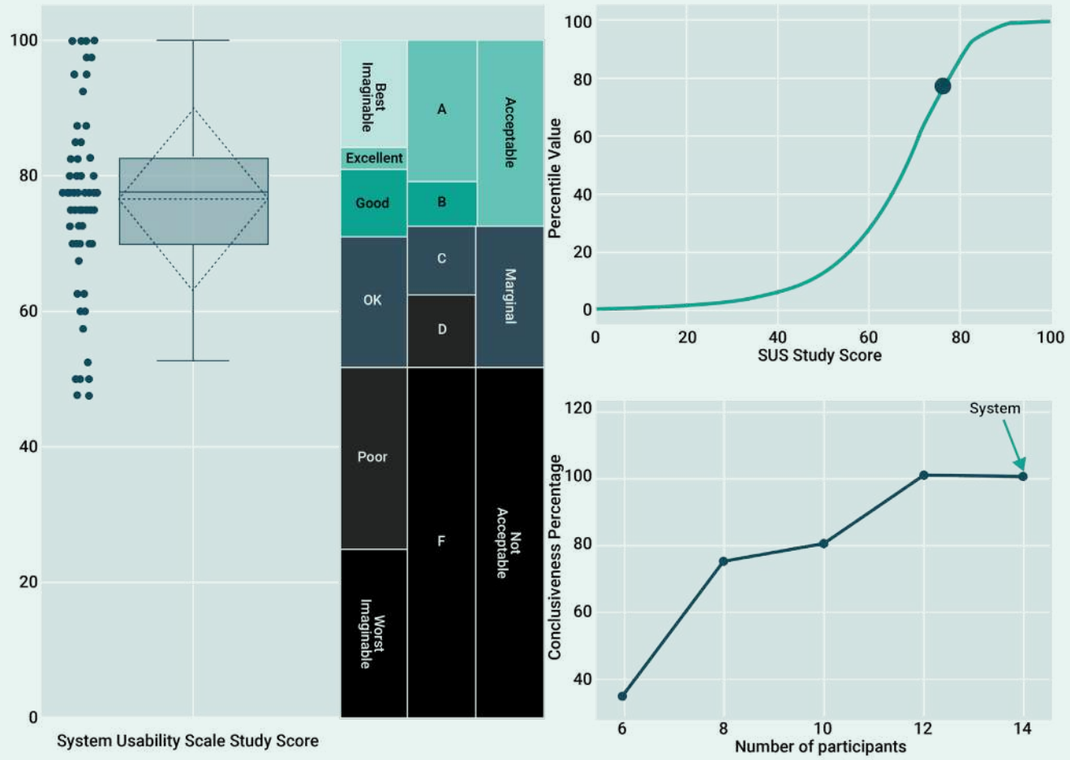
- Scores above 68 are "above average."
- Scores above 80 are "excellent," indicating high perceived usability.

In this evaluation, the SUS scores ranged between 47.5 and 100, reflecting diverse perceptions of usability among users:

- Low SUS Scores: Participants scoring below 68 may have encountered usability challenges, suggesting that the platform could be complex or less intuitive for some groups.
- High SUS Score: Participants scoring 80 or above found the platform highly intuitive and easy to use. Reflecting a cohort of users with very positive usability experiences.

With an overall mean of 76.86, the platform ranks as "good" in usability, above the SUS average of 68 and close to the "excellent" threshold (80+), indicating high user satisfaction. The median score of 77.5 aligns with the mean, further validating the 76.86 as a representative measure of user sentiment. The benchmark, based on over 10,000 responses from numerous products (Sauro & Lewis, 2016), provides a helpful reference. While the benchmark comparison is helpful, it is worth noting that the SUS benchmarks cover a range of industries. Therefore, while scores above 80 are "excellent" in a general sense, comparisons within the digital health or other Respiratory Toolkit would offer a more precise evaluation.

Figure 55. SUS Scores Analysis.



A high percentile value (See Figure 55) reflects that the All Wales ICST platform performs better than most systems evaluated on usability, helping contextualize the SUS score within the broader landscape.

Out of 59 participants, 23 scored 80 or above, signifying a significant group that perceives the product as highly usable. Conversely, 10 participants scored below the typical SUS average threshold of 68, pointing to potential usability issues for some users.

The standard deviation of scores suggests moderate variability, indicating that while the platform is generally rated positively, some users experience the platform differently. As shown in Figure 55, this variability suggests that certain interface elements may be intuitive for some users but less so for others, potentially due to differences in familiarity, technical background, or personal preferences.

The dataset's conclusiveness is strong, given the central clustering around the mean score and the range of responses across the scale. This variability suggests that the data is reflective of a broad user base and is thus robust enough to guide usability improvements. The "System" point in Figure 55 highlights the conclusiveness percentage achieved with the current participant count, indicating high confidence due to the sample size.

3.8.2.1 Conclusion: HCP Usability

The analysis of the All-Wales ICST platform using the UEQ and SUS scales indicates a generally positive user experience, with high scores in both Pragmatic Quality and Hedonic Quality. The average SUS score of 76.86 and high ratings across UEQ dimensions position the platform as "good" to "excellent" in usability, with a significant portion of participants rating it highly intuitive and engaging. This positive feedback suggests that the platform effectively meets the needs of a broad user base, though some areas could benefit from targeted enhancements for new or less technical users.

While the benchmark data provides valuable context, it is worth noting that the products used for comparison are diverse and not direct competitors to the All-Wales ICST platform, which limits the precision of industry-specific insights. In addition, due to averaging across varied user responses in the UEQ, extreme scores (above +2 or below -2) are rare. This can make high scores appear less pronounced, potentially underrepresenting positive user sentiment. Furthermore, while the SUS score is a reliable general measure of usability, it does not provide detailed insights into specific functionalities or user tasks, which limits the ability to identify precise areas for improvement in the user flow.

Overall, these findings provide a strong foundation for understanding user satisfaction with the platform, though future studies could benefit from task-based usability testing and more targeted industry benchmarks to address these limitations.

3.9 Value-analysis

Although the implementation science approach of ICST has led to at least one user of the Healthhub apps in 100% of the main GP practices across Wales, indicating excellent spread, there is still generally low overall uptake among the total asthma and COPD populations in Wales. Only about 6% of individuals with COPD and 5% of individuals with asthma in Wales have downloaded the respective app. This can be partially attributed to the length of time the apps have been available. Since October 2022, the apps have seen continuous growth, with around 6,000 additional users per year. However, at this current rate, it would take approximately 60 years for all individuals with COPD and asthma in Wales to be signed up to the app. This highlights the need for improved strategies to increase uptake.

The All-Wales ICST Platform has been demonstrated to have excellent uptake amongst HCPs, with over 60% of all primary care nurses and GPs and over 40% of all consultants (>90% amongst respiratory) across Wales signed up to the platform.

3.9.1 Value to Patients

Management of Condition

The findings indicated that the Healthhub apps provide tools that effectively support individuals with COPD and asthma to manage their condition. This was reflected through both the patient surveys, PROMs and patient interviews. Survey respondents indicated that using the apps had given them an increased understanding of why it is important to manage their condition (>50% agreed for all three apps) and an increased understanding of how to manage the condition (around 50% agreed for all three apps).

Over 60% of respondents agreed that using the apps increased their opportunity to change their health behaviours through providing easy access to information that helps them self-manage their respiratory condition. Additionally, between 40 and 50% of respondents reported that engaging with the apps made them more motivated to manage their own condition. Results from the 2023 survey supported this, with respondents rating the management of their condition significantly higher since downloading the app compared to before (5.0 (4.0, 8.0) before using the app compared to 7.0 (5.0, 8.0) since downloading the app ($p < 0.001$, $n = 357$).

Importantly, 40-50% of survey respondents across all apps agreed or strongly agreed that the app has reduced their worry or anxiety about their condition. This highlights the potential positive impact the Healthhub apps could have on the quality of life of individuals with asthma and COPD.

Evidence from PROMs collected supported an overall positive impact of the asthmahub app on helping patients with asthma to manage their condition; out of a total of 2,238 patients with repeated asthma checker measurements, there

was a net gain of 88 patients who were managing their condition more effectively between their first and second recorded measurements. If this pattern were repeated for all adults with asthma in Wales, this would equate to a net gain of around 10,027 individuals with asthma managing their condition more effectively as evidenced through improvements in their asthma checker score. Furthermore, these improvements were observed after as little time as 1 month between measurements, and as such, the figure could be much higher if individuals continue to improve the management of the asthma though continuing to use the app over longer periods of time.

The impact of the Healthhub apps on helping patients to manage their condition more effectively was also supported by respondents of the HCP survey, with almost 70% (n = 73) agreeing or strongly agreeing that the health hub apps have helped their patients to manage their condition more effectively.

Data from COPDhub PROMs also supported an improved management of COPD amongst users over time, with the percentage of users reporting not needing to use their reliever inhaler increasing from March 2022 to May 2024, however, numbers were small (n = 77 per month (median)) and changes could be due to responses from different users responding over time, or new people signing up to the app.

A recurring theme in the interviews was the feeling of empowerment for patients to manage their respiratory condition independently and confidently. Users felt that features like peak flow monitoring and medication tracking provided actionable insights, allowing them to manage their health more effectively and seek medical support only when necessary.

Effect on Outcomes
App users reported through both of the surveys carried out that the app has had a positive impact on their health-related outcomes. They noted reductions in GP visits and ED admissions, and many users found their appointments with healthcare professionals more useful since using the app.

The interviews provided some insight into how interactions with the apps could lead to improved outcomes. Co-production was a key theme throughout the interviews; through the resources provided in the app, users achieved a greater understanding of their condition leading to a sense of ownership, which helped users to manage their own health without over-reliance on external interventions.

Users also indicated that they believed features such as free text entries and trend data made their appointments with HCPs more valuable, as they were able to document their experiences and share insights, enabling more informed decision making.

ICST as a Behavior Change System
Although the majority of Healthhub survey respondents indicated that they did not change health-related behaviors, there was an overall shift towards more positive health-related behaviors as a result of the Healthhub apps.

Evidence shows that the ICST toolkit is associated with significant behavior change amongst users through changes in inhaler use. A significant association was observed between use of Healthhub apps and increased low GWP inhaler use. Wales has been much more successful in switching from MDI type inhalers towards the low GWP alternatives than the other home nations, who do not have ICST, and within Wales, data show areas with higher adoption of the Healthhub apps have significantly higher percentage of low GWP inhaler use than areas of lower adoption. This provides further evidence of the capability of the apps in promoting behavior change amongst users. In addition, there was evidence that there were reduced hospital or GP visits which was associated with Healthhub usage.

Overall satisfaction
Overall satisfaction with the apps was high amongst users, although the usability analysis highlighted some improvements that can be made to the apps. While the apps met basic usability needs, the analysis highlighted the potential to improve user satisfaction, particularly by adding more engaging or appealing features.

3.9.2 Value to HCPs

All Wales Platform Resources
The HCP survey indicated strong approval of the ICST respiratory toolkit amongst HCPs in Wales. Approval was universal for all elements of the toolkit (Assessments/ certificates, QI projects, e-mails, events, All Wales guidelines, educational components), with HCPs finding the All-Wales guidelines and educational components particularly valuable (>90% of respondents finding them to be at lease 'somewhat' or 'very' useful).

The value to HCPs was reflected in the interviews, where practitioners stated they felt empowered to deliver consistent, reliable care, ultimately leading to improved patient outcomes. A consistent theme throughout the interviews was that value had been provided in the delivering of high-quality, centralised resources and many HCPs expressed concern about the potential consequences of its absence. Maintaining the platform's availability was seen as essential for sustaining progress in respiratory care.

The role of ICST in promoting standardisation emerged as a recurrent and significant theme during the interviews, with standardisation reducing discrepancies in patient treatment, promoting trust in the system and manifesting in improved clinical outcomes. Healthcare professionals highlighted their reliance on ICST guidelines and modules to train both new and existing staff. For example, respiratory team leaders noted the regular use of ICST tools to maintain clinical standards, ensure staff confidence, and deliver consistent education.

The educational and learning components were seen as having great value to the HCPs interviewed, with the clear guidelines, and assessment tools helping to streamline training processes, allowing staff to focus on improving patient care rather than searching for disparate resources. Moreover, the ability to update training every 18 months ensures knowledge remains current and reflective of best practices. This routine use of ICST not only improves staff competence but also strengthens multidisciplinary team cohesion by providing a shared foundation of clinical knowledge.

Impact on Consultations with Patients
The majority of HCPs (>50%) also stated that they believed the Healthhub apps enabled them to get more out of their consultations with patients. Similar results were obtained from the user survey, with around 30-40% of respondents agreeing that their appointments with HCPs had been more valuable since downloading the app.

During interviews, some of the mechanisms for this were identified, for example, in-app tools such as free text entries and trend data help patients document their experiences and share these insights with healthcare providers, enabling more informed decision-making. In this way, the Healthhub App not only supports patients in achieving better health outcomes but also strengthens the efficiency of professional care.

3.9.3 Value to the NHS in Wales

The ICST respiratory toolkit has brought significant value to the NHS in Wales in several ways. Firstly, it has empowered individuals with asthma and COPD to self-manage more effectively, potentially reducing their need for GP appointments, ED visits, and hospital admissions. Additionally, the toolkit has played a crucial role in promoting the use of low GWP inhalers, supporting the decarbonisation agenda.

The toolkit is also part of a wider infrastructure created by ICST to deliver educational materials, training and guidelines to staff across Wales, which allows rapid delivery of evidence-based materials. The various ways in which the toolkit benefits the NHS in Wales are detailed below.

Effect on Respiratory Outcomes Across Wales
Although the raw data did not conclusively show a significant effect on outcome measures, both the 2023 ICST Healthhub survey and the 2024 TriTech/ATiC Healthhub surveys indicated that app users experienced overall improved outcomes, including reduced use of clinical services.

Across all three apps for the 2023 Healthhub survey, 82 (22%) indicated that their number of GP visits had decreased with 24 (7%) indicating that their number of GP visits had increased since using the app (n = 368). Additionally, 58 (16%) indicated that their number of admissions to the ED had decreased, and 7 (2%) indicated that their number of admissions

to the ED had increased since using the app (n = 367). This equates to a net of 58 (15.8%) patients with improved outcomes in terms of reduced GP visits and a net of 51 (13.9%) patients with improved outcomes in terms of reduced admissions to the ED.

Results were similar for the 2024 TriTech/ATiC survey, with 135 (16.4%) indicating their number of visits to clinical services had decreased since using the app and 35 (4.3%), indicating their visits to clinical services had increased. This equates to a net of 100 (12.1%) of patients who experienced an improvement in terms of their requirement for clinical services.

If each of these individuals had one fewer GP appointment per year (unit cost £42, Jones et al., 2024) and one fewer ED attendance (unit cost £273, NHS England 2024), this equates to a resource release of between £2,436 and £4,200 for GP appointments and between £13,923 and £27,300 for ED attendances annually (total between £16,359 and £31,500).

However, the net current benefit could be much higher, as these figures are restricted to survey respondents only. If the benefits were to extend to the entire userbase (n = 18,572), resource release would be between £94,374 to £123,228 for reduction in GP appointments and between £613,431 to £704,886 for reduced ED attendances (combined total £707,805 to £828,114).

If the apps were adopted by all individuals with asthma and COPD in Wales (n = 388,000), and similar benefits were experienced, the resultant resource release would be equivalent to between £1,971,816 and £2,574,768 for GP appointments and between £12,816,804 and £14,723,436 for ED attendances annually. This highlights the potential of the toolkit if adoption can be accelerated across Wales.

It should be noted that the cost of hospital admissions resulting from ED attendance has not been considered. A significant number of patients presenting to the ED with COPD or asthma ultimately require costly hospital admission. Additionally, there is a level of uncertainty with the projected economic benefits, as these figures were obtained by extrapolating from relatively small survey numbers, with an assumption that all app users would experience similar benefits to those who responded to the survey.

Inhaler Switching and Environmental Impact of the Toolkit

Evidence indicates that the toolkit, through mechanisms like guidelines and educational materials, has played a significant role in promoting the transition to low GWP inhalers in Wales. This has culminated in Wales having significantly greater success at switching towards the low GWP inhalers than the other home nations, and importantly, has contributed to the decarbonisation agenda across Wales and the NHS Wales target of switching to 80% low GWP inhalers by 2025.

GP practices that had high adoption of the Healthhub apps had a significantly lower carbon footprint for inhalers dispensed per 1,000 patients than GP practices with low adoption of the Healthhub apps. A 57% reduction in carbon footprint for inhalers dispensed per 1,000 patients was observed in high adopting practices from 2018 to 2023. Across Wales, a 26.0% reduction was observed. If high-adopting practices were replicated nationwide, it would result in an additional reduction of approximately 19,969,638 CO2kg equivalent per annum. This is comparable to driving a medium-sized petrol car a distance equivalent to the moon and back 146 times or around the Earth's circumference 2,801 times (UK Government, 2023). The equivalent social cost of this carbon, considering socioeconomic projections, climate models, damage functions and discounting methods that collectively reflect theoretically consistent valuation of risk is estimated at $3,694,383.03 ($878,664.07 - $8,247,460.49; 5 – 95% range, 2020 US dollars) (Rennert et al., 2022).

Educational and Training Value Across Wales

The ICST framework has been used to successfully deliver education and training to staff at scale. One example is the spirometry training conducted with staff throughout Wales. Powys was chosen as the initial implementation site, and it proved highly successful, attracting more practitioners to the new training model than any other health board. Following the success of the ICST delivery in Powys, the ICST training model was implemented across the other health boards, with similar success of improved enrolment, reduced cost and faster implementation than traditional training models (Barry, 2018). This highlights the potential for ICST to deliver education and training to HCPS quickly, on demand and at scale.

Additional value

The aim of the ICST toolkit is to develop a behaviour change system agnostic of condition. In addition to the three components of the respiratory toolkit, there are other initiatives delivered through the ICST infrastructure that provide additional value to the project.

For instance, the ICST toolkit implementation framework was used to deliver COVID-19 hospital guidance across NHS Wales via a clinical guideline platform. A total of 46% of consultants across Wales registered with the guideline platform, which offers 180 pre-recorded video tutorials by 45 clinical specialists, all accessible online. The use of the ICST toolkit implementation framework demonstrated that guidelines can be created and disseminated rapidly and on a large scale (Jeffries et al., 2022).

The digital implementation framework was subsequently utilised to develop and disseminate a TB screening guideline for Ukrainian arrivals to Wales. 1955 Ukrainian refugees were screened for TB through the pathway, of which 112 tested positive (Barry et al., 2023). This demonstrates the value of the implementation framework to create change at scale and pace, and how the ICST implementation framework can be effectively utilised across other disease areas.

Additionally, tracheostomy training was accessed by thousands of HCPs across Wales using the ICST framework, even though this was not mandated (Twose et al., 2024).

Broader Societal Impact

There is additional value of the toolkit in terms of broader societal impact. Although it was beyond the scope of this evaluation, it should be acknowledged that improved patient wellness and quality of life due to the toolkit could also lead to societal benefits such as increased ability for individuals to work or increased productivity.

An overall assessment of the value the ICST respiratory toolkit provides is shown in Figure 56 below. Actual figures are likely to be higher due to a significant number of patients presenting to the ED with COPD or asthma requiring costly hospital admissions, which was not included in the analysis due to a lack of data.

Figure 56. ICST Respiratory Toolkit Overall Value Assessment

Cost

Indicative renewal costs:
£600,000 per annum

Estimated Monetary Value (Resource Release)

Strong Evidence:

Estimated 51 to 100 fewer ED attendance per annum, £13,923 to £27,300
Estimated 58 to 100 fewer GP consultations per annum, £2,436 to £4,200
TOTAL: **£16,359** to **£31,500**

Moderate Evidence:

Estimated 2247 to 2582 fewer ED attendance per annum, £613,431 to £704,886
Estimated 2247 to 2934 fewer GP consultations per annum, £94,374 to £123,228
TOTAL: **£707,805** to **£828,114**

Potential Impact (Subject to 100% National Adoption):

Estimated 46,948 to 53,932 fewer ED attendance per annum, £12,816,804 to £14,723,436
Estimated 46,948 to 61,304 fewer GP consultations per annum, £1,971,816 to £2,574,768

TOTAL: **£14,788,620** to **£17,298,204**

Additional Value (non-monetary)

Strong Evidence:

- The toolkit helps people with asthma and COPD to manage their condition more effectively.
- The toolkit promotes co-production and enhances care for users.
- The guidelines promote standardisation and an evidence-based approach to care.
- The Toolkit contributed to inhaler switching and the decarbonisation agenda.

Moderate Evidence:

- The toolkit helps improve quality of life amongst individuals with asthma and COPD.
- The toolkit has a positive effect on patient wellbeing.

Potential Impact (Subject to 100% National Adoption):

Estimated 19,969,638 kg CO2 equivalent
Equivalent Social Cost:
£702,931.26 to **£6,597,968.39**

4 Discussion and Conclusions

4.1 Discussion

Tritech's evaluation of the ICST toolkit focused on assessing its impact on service users and healthcare professionals, as well as its value to the Welsh health ecosystem. The ICST respiratory toolkit is an ambitious project aimed at transforming respiratory care across Wales. Below is a summary of the key aspects of the evaluation.

4.1.1 Uptake of the respiratory Toolkit

Adoption of both the patient-facing apps and staff-facing dashboard are underpinned by implementation science methodology and the development of the ICST implementation framework. The framework has been successfully utilised to achieve adoption of a national COVID-19 guideline (Jefferies et al., 2022), a national TB screening pathway for Ukrainian refugees (Barry et al., 2023) and a national tracheostomy toolkit (Twose et al., 2024) and serves as the foundation for the spread and scale methodology of the respiratory toolkit.

Coverage of the apps across Wales was found to be extensive, with at least one asthma or COPD patient using one of the apps in 100% of the main GP practices in Wales, and a median of 34 users at each surgery (max 285). Although uptake on a population level is quite low, with around 5-6% of people with asthma and COPD using the apps, there is a good foundation to scale, strengthened by clinical backing and excellent uptake of the staff-facing components of the toolkit. The evaluation found that geographical location (determined by GP practice location) was an indicator of the number and percentage of individuals using the app, with the highest relative uptake of the apps in the South and West of Wales. There were no major correlations between deprivation and uptake in the majority of health boards, with only ABUHB having a significant correlation between uptake of COPDhub and deprivation, indicating a lower uptake of the COPDhub app in deprived areas in ABUHB. To improve uptake, ICST could focus on areas in Wales with the lowest engagement, particularly those with high deprivation. It has been shown in preliminary data that individuals in the more deprived areas experience the most benefit from the apps (Barry et al., pre-publication), highlighting the potential impact of increasing uptake in these areas. Although the app currently gains around 6,000 new users annually, this is relatively low compared to the total population of asthma and COPD patients in Wales. However, a linear increase has been maintained since launch despite uncertainties surrounding funding and continued support of the toolkit. Efforts could be redirected to increase the annual uptake, including measures to ensure awareness and full support of the toolkit at a national level.

HCP uptake of the All-Wales ICST Platform was found to be excellent, with around 60.1% of all GPs, 61.4% of all primary care nurses and 42.9% of all consultants in Wales (>90% with respiratory specialism) signed up to the platform. When comparing patient uptake with areas of high uptake amongst primary care HCPs, uptake amongst primary care was found to be a significant predictor of the number of patient users at any given GP practice. The number of registered healthcare professionals (HCPs) at a GP practice was a stronger predictor of patient app sign-ups than the number of COPD and asthma patients registered at the practice. Therefore, a key strategy to increase uptake will involve engaging more HCPs to promote the apps to their patients.

4.1.2 Impact of the Toolkit on Patients

The results of the patient surveys show that responders reported a significant improvement in their perceived ability to manage their condition since downloading the app. Furthermore, when patients' perspectives of the app where explored (COM-B) the majority of responders agreed that the apps helped them: increase opportunity to change their health behaviours; and increase their capability to understand and manage their condition. The majority of participants indicated that they were satisfied with the overall experience of using the apps and most respondents stated they would recommend the Healthhub apps to others.

As part of the evaluation user interviews were carried out. The interviews with users identified 4 important key themes: 1) Empowering Patients to Take Charge: the users commented that the apps were empowering and helped them manage their respiratory health independently and confidently; 2) Effortless Use, Hidden Hurdles: the majority of users stated the Healthhub App is intuitive and easy to use; 3) Unlocking the Potential of Key Features; users reported that while core features like peak flow monitoring and medication tracking are well-utilised and valued, other functionalities of the Healthhub app remain underexplored; and 4) Personalizing Self-Management Tool: users highlighted the Healthhub Apps effectiveness in supporting self-management varies, reflecting the differing needs, preferences, and conditions of patients.

4.1.3 Effect of the toolkit on patient outcomes

In addition to the surveys, Patient Recorded Outcome Measures (PROMs) were also collected routinely through the Healthhub apps.
This was achieved through the asthmachecker and COPDchecker in the respective apps. In general, engagement with the checker tools was not found to be good, with the majority of users not completing the checker survey, or only completing it once. However, those that completed the checker surveys indicate overall improved asthma and COPD control after using the app, this is also indicated by the results from the RCP PROM questions for the Asthmahub users.

The biggest limitation of the evaluation was the lack of direct evidence showing the apps' impact on reducing hospital admissions or improving patient wellbeing. Due to data governance issues, there is no robust national data comparing app usage with hospital admissions. Additionally, only 4-6% of people with asthma or COPD in Wales have engaged with the Healthhub apps, making significant trends in health board-wide statistics unlikely. Despite this, surveys indicate reductions in healthcare system visits: Asthmahub (16%), COPDhub (12%), and Asthmahub for parents (10%).

Furthermore, the Asthmachecker and COPDchecker PROM collections showed a net reduction in GP visits (6%) and ED admissions (14%) after using the app. Whilst not conclusive there are several pieces of evidence that suggest the Healthhub apps may have potential in reducing ED/GP visits with a potential time/cost savings. If the ICST platform is re-commissioned it would be advisable to explore a mechanism by which to track hospital or GP admissions for Healthhub users.

4.1.4 Effect of the toolkit on inhaler use

Throughout the evaluation several elements indicate that the ICST platform has played an important role in improving inhaler use across Wales. Currently Wales is outperforming the other home nations in the reduction of high GWP inhaler use. When comparing uptake of the ICST apps and the usage of DPI and SMI inhalers for each year, there was a significant correlation. Interestingly, the relationship between the increased use of DPI and SMI inhalers and increase in ICST app users at a practice level, grew stronger each following year, furthermore, there was no correlation in 2018 before the respiratory toolkit was implemented. To further investigate this relationship, the top adopting practices were compared to the bottom adopting practices. It was seen that there was a significantly higher proportion of DPI/SMI inhaler prescriptions in the top adopting practices of the toolkit. These findings support the responses recorded from both the user surveys carried out which indicated improved inhaler use. The survey results indicated a reduction in inhaler use for the Asthmahub users (net reduction of 17%) and the COPDhub users indicated a reduction of 3.5%. One positive outcome from the Asthma checker and COPD checker is an increase over time of app users reporting that they do not need to use their reliever inhaler.

As a result of the noted changes in inhaler usage and change to DPI/DMI inhalers there has been a positive impact on the environment. The carbon footprint of inhalers dispensed on prescriptions were significantly lower for high adopting practices of the Healthhub apps, for all years from 2018 to 2024 compared to low adopting practices of the Healthhub Apps. Practices that were low adopters of the Healthhub apps had a significantly higher carbon footprint for inhalers dispensed on prescriptions per 1000 patients. Although both high adopting and low adopting practices managed to reduce their carbon footprint, high adopting practices had a reduction of 57% whereas low adopting practices had a reduction of 21.2% per 1000 patients from 2018 to 2023. Across the whole

of Wales, GP practices reduced their carbon footprint for inhalers dispensed from 1,726 ± 671 CO2kg equivalent in 2018 to 1,278 ± 517 CO2kg equivalent in 2023. The additional reduction in CO2 equivalent for high adopting practices, if achieved for the whole of Wales would equate to an estimated 19,969,638 CO2kg equivalent.

4.1.5 Impact on Health Care Professionals

As part of the evaluation, a survey was distributed to respiratory professionals (HCPs) across Wales to gather their perspectives on the All-Wales ICST platform. The feedback was positive, with most respondents believing that the apps enhanced their consultations with patients and helped patients manage their conditions more effectively

Results from interviews with HCP's working in Primary care provided 4 key themes. 1) Standardising Clinical Practice: the general consensus from the HCP's was that the ICST platform facilitated the dissemination and standardisation of practice; 2) Empowering Practitioners and Patients: The HCPs noted that the platform helped them in the management of their duties and had a positive effect on patient users; 3) Accessible and User-Friendly Platform: another buy benefit identified by HCPs was the ease of access and usability of the platform; and 4) Sustaining and Enhancing Impact: HCPs emphasized the platforms value in delivering high-quality, centralized resources and expressed concern about the potential consequences of its absence.

Results from the interviews with HCP's working in secondary care provided 4 key themes. 1) Empowering Excellence Through Training: HCP's really valued the ICST platforms role in facilitating standardised and up to date training materials; 2)Consistency That Builds Confidence: HCP's also recognised the role of the platform in standardising care across secondary care settings and empowering both practitioners and patients; 3) Bridging Barriers Through Accessibility: The HCPs praised the platform for its layout and ease of accessibility; and 4) Enhancing Integration for Holistic Care: HCP's also highlighted that for the platform to be even more useful integration with other care systems across the health board would be required.

To evaluate the utility of the commissioner's dashboard, interviews were conducted with all available commissioners. The findings revealed that commissioners were more likely to engage with the dashboard during the commissioning process and preferred receiving detailed reports via email afterward. Commissioners appreciated the frequency and format of the reports they received.

4.1.6 Usability Analysis of the ICST Respiratory Toolkit

A usability analysis (UEQ & SUS) was carried out as part of the Healthhub 2024 survey for both patient users and HCP's. The analysis of the ICST Healthhub apps for patients highlights a generally functional but moderately engaging user experience for patients. The usability results suggest that while the Healthhub apps meet basic usability needs, there is room for improvement, particularly in enhancing user engagement and emotional impact. The content analysis regarding most useful features and suggestions for improvements reveals that while users find the apps beneficial for tracking and managing their health conditions, there are consistent suggestions for improving usability, technical performance, and integration with other platforms. Enhancing the apps' user interfaces, resolving technical issues, and increasing personalisation could address these concerns and improve user satisfaction. To elevate the app's usability and emotional appeal, targeted improvements could focus on enhancing engagement and providing support features that simplify the experience for new or less technical users.

By comparison, the results from the usability analysis from the All-Wales ICST platform for HCP's indicates a generally positive user experience. The platform was rated as "good" to "excellent" in usability, with a significant portion of participants rating it highly intuitive and engaging. This positive feedback suggests that the platform effectively meets the needs of HCPs, though some areas could benefit from targeted enhancements for new or less technical users. Overall, these findings provide a strong foundation for understanding user satisfaction with the platform, though future studies could benefit from task-based usability testing and more targeted industry benchmarks to address these limitations.

4.1.7 Value assessment of the ICST platform

Although the raw data did not conclusively show a significant effect on outcome measures, The evidence from the survey and qualitative work indicates a perspective positive impact and added value of the respiratory toolkit for patients and staff. Where a positive impact on health-related outcomes is reported and staff feeling empowered and delivering high quality evidence-based care. This equates to a net of 15.8% patients with improved outcomes in terms of reduced GP visits and a net of 13.9% patients with improved outcomes in terms of reduced admissions to the ED. Extrapolating to all individuals with asthma and COPD in Wales (n = 388,000), if this equated to one fewer GP appointment per year (unit cost £42 (Jones et al, 2024)), and one fewer ED attendance (unit cost £273 (NHS England, 2024)), this would equate to resource release equivalent of between £1,971,816 and £2,574,768 in terms of GP appointments and between and £12,816,804 and £16,735,992 in terms of ED attendances annually. As these figures do not include the potential reduction in hospital admissions, the actual resource release would likely be much higher.

4.2 Conclusions

The toolkit has achieved widespread adoption across Wales and has continuously grown its user base since launch. Overall uptake of the patient-facing apps remains low, and growth of the user base must be targeted to realise the potential of the toolkit, however, there is a good foundation to scale, with both excellent reach and HCP adoption across Wales. Both the patient-facing Healthhub apps and staff-facing components of the toolkit received high satisfaction ratings. Significant evidence highlights the toolkit's value in helping individuals with asthma and COPD manage their conditions more effectively, reducing healthcare service use, and lowering anxiety and worry about their conditions. Healthcare professionals (HCPs) also strongly support the toolkit, particularly valuing the All-Wales guidelines and educational components.

Significant evidence supports the toolkit's impact on switching from high global warming potential inhalers to low global warming potential inhalers. This reinforces the toolkit's value in supporting the green agenda and working towards the NHS Wales target of reducing high global warming potential inhalers to 20% of all inhalers prescribed by 2025. Additionally, there is evidence suggesting that the Healthhub apps may have influenced ED or GP visits.

Staff interviewed expressed a strong desire for the platform's continuation. Participants consistently recognised the toolkit's value in providing high-quality, centralised resources and voiced concerns about the potential consequences of its absence. The platform's guidelines and tools were seen as crucial in reducing variability in clinical practice across different settings and roles, ensuring consistent and high-quality care across Wales. Maintaining the platform's availability is considered essential for sustaining progress in respiratory care.

Overall, ICST has developed a platform with strong support from healthcare professionals (HCPs) across Wales. The platform can rapidly develop and disseminate new evidence-based guidance and has an established user base among individuals with COPD and asthma, who are benefiting from the apps as evidenced by improvements in various respiratory metrics. ICST has received substantial recognition for the development and success of the toolkit through the receipt of numerous national (Wales and UK-wide) awards (Appendix 15) and additionally, all three of the apps were classified as 'good' during an independent ORCHA review (Appendix 16). If the adoption of the Healthhub apps continues to grow across Wales, it is anticipated that this could lead to a significant, detectable impact on patient outcomes and reduce healthcare resource utilisation.

4.3 Limitations of the Evaluation

Some of the outcome's data provided by DHCW was poorly coded, potentially leading to inaccuracies. Additionally, due to the inability to link ICST data with NHS data, most outcomes analysis relied on correlative analysis, which does not imply causality. It is important to note that high adopting practices of the toolkit could simply be high-performing practices in general, leading to positive outcomes irrespective of ICST adoption. It was not possible to separate practice performance and adoption levels in the evaluation.

The lack of engagement from GP practices across Wales made it challenging to fully assess the toolkit's impact on primary care, especially regarding patient outcomes. Although some primary care analysis was possible with data provided by ICST, the results were inconclusive due to incomplete data sets.

Some of the available data in Wales is not recent; this can be evidenced by the WIMD scores, which are from 2019, and as such, deprivation in the different areas could have changed at the time of the evaluation.

There is a level of uncertainty with the projected economic benefits of the toolkit. These figures were calculated by extrapolating from relatively small survey numbers, with the assumption that all app users would experience similar benefits to those who responded to the survey. Due to a lack of data, it was also not possible to determine the impact of the toolkit on hospitalisations, which could be an additional significant resource release.

The lack of integration between ICST data and NHS records limited the effective evaluation of patient outcomes. Linking ICST data with NHS records is essential for accurately assessing the impact on patient outcomes. Future efforts should focus on integrating data from these platforms where possible to ensure a Value-Based approach to adoption.

4.4 Recommendations

Recommendation 1: Currently, only a small percentage (6%) of potential users in Wales are using the apps. While there is steady year-on-year uptake, strategies need to be implemented to increase this. System processes/incentives should be provided to ensure a rapid rollout of the ICST toolkit elements to ensure maximum impact. Efforts should focus on ensuring HCPs are confident in the long-term support of the toolkit and are engaged in promoting the apps to service users, as their engagement appears to drive patient interaction. Additionally, attention should be given to areas in Wales with slower uptake.

> **Recommendation 1.1:** Some evidence indicates a lower uptake of the COPDhub app in deprived areas. To ensure equitable adoption across Wales, efforts should be made to promote the app in deprived regions, particularly in the Aneurin Bevan University Health Board, where the disparity was most pronounced.
>
> **Recommendation 1.2:** Ensure system processes/incentives and support at a national level are in place to sustain engagement with the toolkit. Increasing user engagement and therefore impact is key to value for money.

Recommendation 2: Should the respiratory toolkit continue to be commissioned, the information provided to commissioners should shift to focus on patient outcomes, aligning with the principles of Value-Based healthcare.

Recommendation 3: Explore the potential for integrating the Healthhub apps with other healthcare Digital systems across Wales. Additionally, integrate the ICST datasets with NHS datasets where possible to ensure a fully implemented Value-Based approach to adoption.

Recommendation 4: Explore ways to enhance the usability, visual appeal and personalisation of the Healthhub apps, in ways that are aligned with the primary medical purpose of the apps.

Recommendation 5: Conduct app-specific usability testing to identify the challenges for lower-scoring user groups and prioritise the necessary refinements.

Recommendation 6: Enhance the onboarding processes for the Healthhub apps to ensure new users can easily discover and utilise key features like peak flow diaries, trend lines, and can easily identify their inhaler type and track their inhaler use effectively through the apps.

Recommendation 7: Evaluate the design elements of the Healthhub apps. For instance, assess and refine unclear question phrasing and consider adding a "Not Applicable" option to maintain user engagement.

Recommendation 8: Explore adding new features to Healthhub, such as enabling patients to customise notifications, set personal goals, or concentrate on specific health issues like stress-induced asthma or exacerbation triggers. Additional tools, such as prompts for managing exacerbations or environmental tracking (e.g., air quality), would be desirable to further enhance personalized care, however, the potential to personalise could be limited by medical device regulation.

Recommendation 9: It is vital that the All Wales guidelines continue to be maintained and are widely accessible for HCPs to ensure equitable and evidence-based respiratory care across Wales.

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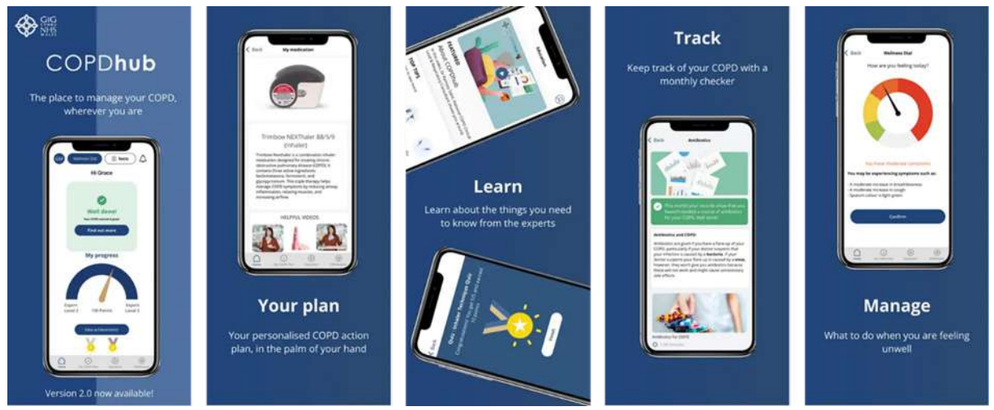
Appendices

Appendix 1: NHS Wales COPDhub App Information

NHS Wales COPDhub



COPDhub empowers you to have a better understanding and a greater involvement in the management of your COPD. This enables you and your healthcare professional to make informed clinical decisions together, reducing unnecessary visits and exacerbations.

COPDhub is developed and updated in collaboration with NHS COPD specialists and patients. It is designed to support you to stay well and to spot when your COPD is deteriorating before any urgent action is required.

This app is recommended for adults over the age of 18 with a diagnosis of COPD, irrespective of how severe or under control their COPD may be.

This app is freely available for those in Wales.

Features:

- A digital COPD plan that you can export to a pdf and keep saved on your phone to use with or without internet.
- A monthly COPD Checker to monitor your control in between annual reviews.
- A decision support tool to help manage your symptoms
- Expert patient badges, designed to help you become an expert in managing your condition.
- MRC/CAT score functionality
- General education about keeping you well
- A log of important COPD information to export and discuss with your healthcare professional
- Diary and Reminders functionality
- Your COPD contacts list
- A checklist to ensure you receive the very best care when visiting your GP or attending hospital appointments.
- An option for Healthcare Professionals to easily sign up

Registration with the app is free and involves putting in minimal information to ensure the app is personalised to you. No information is shared with any third party, but anonymised data will support improvement efforts to local clinical services and it may also contribute towards population-based COPD research.

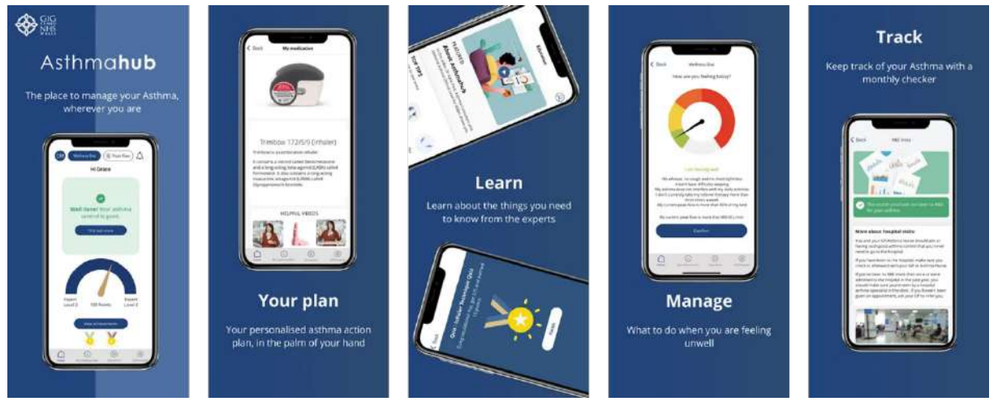
If you have any questions about the app, please contact us at support@healthhub.wales, we aim to reply within 3 working days.

The information and advice on this app are put together and updated by specialists within the NHS, so it is always as accurate as possible. The content and education in the App is provided for general information and it is not intended to amount to advice on which you should solely rely upon. Always seek advice from your healthcare practitioner.

Download the app now, take control of your COPD.

Appendix 2: NHS Wales Asthmahub App Information

NHS Wales Asthmahub



Helping keep you symptom free and in control of your asthma care.

Asthmahub empowers you to have a better understanding and a greater involvement in the management of your asthma. This enables you and your healthcare professional to make informed clinical decisions together, reducing unnecessary visits and exacerbations.

Asthmahub is developed and updated in collaboration with NHS asthma specialists and patients. It is designed to support you to stay well and to spot when your asthma is deteriorating before any urgent action is required.

This app is recommended for adults over the age of 18 with a diagnosis of asthma, irrespective of how severe or under control their asthma may be.

This app is freely available for those in Wales.

Features:

- A monthly Asthma Checker to monitor your asthma control in between annual reviews.
- A decision support tool to help manage your symptoms
- Peak Flow diaries
- General education about keeping you well and symptom-free
- A log of important asthma information to export and discuss with your healthcare professional
- Diary and Reminders functionality
- Expert patient badges, designed to help you become an expert in managing your condition.
- Your asthma contacts list
- A checklist to ensure you receive the very best care when visiting your GP or attending hospital appointments.
- An option for Healthcare Professionals to easily sign up

Registration with the app is free and involves putting in minimal information to ensure the app is personalised to you. No information is shared with any third party, but anonymised data will support improvement efforts to local clinical services and it may also contribute towards population-based asthma research.

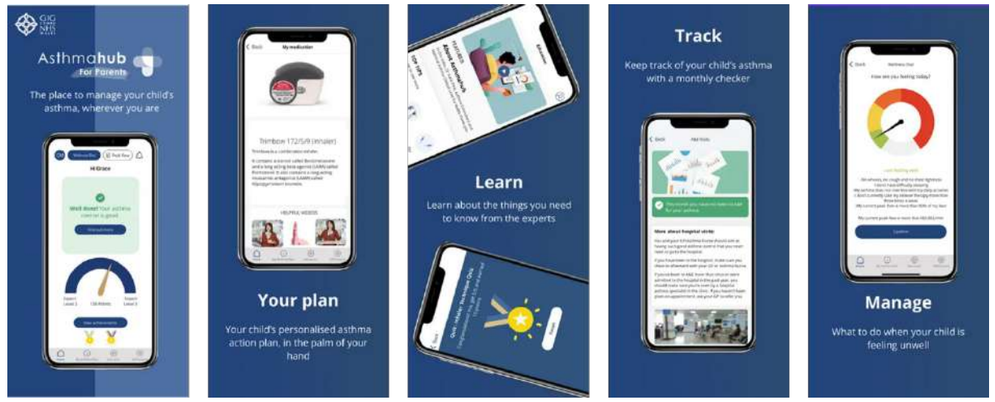
If you have any questions about the app, please contact us at support@healthhub.wales, we aim to reply within 3 working days.

The information and advice on this app are put together and updated by specialists within the NHS, so it is always as accurate as possible. The content and education in the App is provided for general information and it is not intended to amount to advice on which you should solely rely upon. Always seek advice from your healthcare practitioner.

Download the app now and take control of your asthma.

Appendix 3: NHS Wales Asthmahub for parents App Information

NHS Wales Asthmahub for Parents



Asthmahub for Parents empowers you and your child to have a better understanding and a greater involvement in the management of your child's asthma. This enables you and your healthcare professional to make informed clinical decisions together, reducing unnecessary visits and exacerbations.

Asthmahub for Parents is developed and updated in collaboration with NHS asthma specialists and patients. It is designed to support your child to stay well and to spot when their asthma is deteriorating before any urgent action is required.
This app is recommended for all children with a diagnosis of asthma, irrespective of how severe or under control their asthma may be. This app is freely available for those in Wales.

Features:

- A monthly Asthma Checker to monitor your child's asthma control in between annual reviews.
- A decision support tool to help manage your child's symptoms
- Peak Flow diaries
- Expert patient badges, designed to help you become an expert in managing your child's condition.
- General education about keeping your child well and symptom-free
- A log of important asthma information to export and discuss with your healthcare professional
- Diary and Reminders functionality
- Your asthma contacts list
- A checklist to ensure your child receives the very best care when visiting your GP or attending hospital appointments.
- An option for Healthcare Professionals to easily sign up

Registration with the app is free and involves putting in minimal information to ensure the app is personalised to you. No information is shared with any third party, but anonymised data will support improvement efforts to local clinical services and it may also contribute towards population-based asthma research.

If you have any questions about the app, please contact us at support@healthhub.wales, we aim to reply within 3 working days.

The information and advice on this app are put together and updated by specialists within the NHS, so it is always as accurate as possible. The content and education in the App are provided for general information and it is not intended to amount to advice on which you should solely rely upon. Always seek advice from your healthcare practitioner.

Download the app now, take control of your child's asthma.

Appendix 4: 2023 ICST Healthhub App Feedback Survey Questions

1. **How long have you been using the app for?**
    a. Less than 1 month.
    b. 1 – 3 months.
    c. 3 – 6 months.
    d. 6 – 12 months.
    e. More than 12 months.
    f. Other (please specify).
2. **How often are you using the app?**
    a. Every day.
    b. A few times a week.
    c. About once a week.
    d. A few times a month.
    e. Once a month.
    f. Less than once a month.
3. **Prior to downloading the app, how well was your condition managed?**
    Semantic scale of 0 to 10.
    0 – Poorly (symptom deterioration and flare-ups).
    10 – Excellently (no symptom deterioration/flare-ups).
4. **Since downloading the app, how well is your condition being managed?**
    Semantic scale of 0 to 10.
    0 – Poorly (symptom deterioration and flare-ups).
    10 – Excellently (no symptom deterioration/flare-ups).
5. **How often are you having to visit the GP as a results of your respiratory?**
    a. The number of visits has not changed.
    b. The number of visits has increased.
    c. The number of visits has decreased.
    d. Other
6. **Compared to before you had the app, how do you feel the app has impacted the number of A&E visits you have needed to have because of your respiratory condition?**
    a. My admissions have not changed.
    b. My admissions have increased.
    c. My admissions have decreased.
    d. Other.
7. **Do you have anything else regarding the apps that you would like to add**
    Open ended question.

Appendix 5: TriTech/ATiC Healthhub Survey Patient Questions

Evaluation of the Respiratory Toolkit App - English

Start of Block: Consent

Q17 **Evaluation of the Institute of Clinical Science and Technology (ICST) Respiratory App**
What is the purpose of the evaluation? Tritech and UWTSD's Assistive Technologies Innovation Centre (ATIC) are carrying out a service evaluation of the ICST Health Hub Respiratory Apps (COPDHub, AsthmaHub and AsthmaHub for Parents). We are seeking patients with respiratory conditions such as Asthma or Chronic Obstructive Pulmonary Disease (COPD) to help us evaluate the Apps. We want to find out how much the Apps are being used across Wales and what patients think about them. To do this we need patients (aged 18 or over) who have and have not used the Apps to complete this short survey.
What happens if I agree to take part? Taking part is voluntary. You will be asked to answer some questions about what you think about the Health Hub Apps (even if you have never used them) which should take no longer than 5 minutes of your time. You can change your mind about taking part at any point during the survey by simply closing your browser.
What happens to the information I give you? All data collected will be anonymous, cannot be traced back to you, and will be stored securely in line with data protection regulations. For further information please read this information sheet. If you have any questions, please feel free to contact Dr Gareth Davies at gareth.davies14@wales.nhs.uk

Q18 By clicking on the "I Agree" button below, you acknowledge that you have read and understood this information sheet and agree to participate in the online survey.

- ○ I Agree
- ○ I Don't Agree

Skip To: End of Survey If By clicking on the "I Agree" button below, you acknowledge that you have read and understood this... = I Don't Agree

End of Block: Consent

Start of Block: Demographics block 07.08.24

Q1 Please select your gender

- ○ Male
- ○ Female
- ○ Non-binary - Third Gender
- ○ Prefer to self-describe

_____

*

Q2 Please enter your age:

_____

Q3 Where do you live in Wales?

- ○ Blaenau Gwent

_____

- ○ Bridgend
- ○ Caerphilly
- ○ Cardiff
- ○ Carmarthenshire
- ○ Ceredigion
- ○ Conwy
- ○ Denbighshire
- ○ Flintshire
- ○ Gwynedd
- ○ Isle of Anglesey

_____

- ○ Merthyr Tydfil
- ○ Monmouthshire
- ○ Neath Port Talbot
- ○ Newport
- ○ Pembrokeshire
- ○ Powys
- ○ Rhondda Cynon Taff
- ○ Swansea
- ○ Torfaen
- ○ Vale of Glamorgan

- ○ Wrexham

Page Break

Q78 What is your ethnic group? Please choose one option that best describes your ethnic group or background.

- ○ White/White British
- ○ Mixed/Multiple Ethnicity
- ○ Asian/Asian British
- ○ Black/African/Caribbean/Black British
- ○ Any other ethnic group (please describe) _____

Q6 What is your marital status?

- ○ Single (never married)
- ○ In a committed non-marital relationship
- ○ Married/ common law/domestic partnership
- ○ Civil partnerships
- ○ Widow / Widower
- ○ Divorced

Q7 Education Status

- ○ Left school at 16 with no qualifications
- ○ GCSE/O-level or equivalent
- ○ A-level/BTEC or equivalent
- ○ Undergraduate or equivalent (Degree, HNC/HND etc)
- ○ Postgraduate or higher
- ○ Prefer not to say

Page Break

End of Block: Demographics block 07.08.24

Start of Block: Initial Screen

initial screening Do you use any of the Health Hub Apps (COPDHub, AsthmaHub, AsthmaHub for parents)?

- ○ Yes
- ○ No

End of Block: Initial Screen

Start of Block: Non-user questions

Q43 Please tell us why you do not use the App?

- ☐ I am not aware of it/I have never heard of it
- ☐ I do not like using Apps
- ☐ I was advised not to use it by my healthcare professional
- ☐ I do not think I need to use the App
- ☐ I do not have asthma/COPD
- ☐ Other (please state) _____

Q44 Would you be interested in using the App?

- ○ Yes
- ○ No
- ○ Not sure

Q45 If you would like to tell us anything else about your reasons for not using the App please do so here.

_____

End of Block: Non-user questions

Start of Block: non-user debrief

Q63 If you wish to withdraw your data now, please just close this browser. Otherwise, please select the NEXT button below to record your responses. If you have any questions or concerns, please contact us on the email below. Thank you for taking the time to complete this service evaluation. Dr Gareth Davies: gareth.davies14@wales.nhs.uk

Skip To: End of Survey If If you wish to withdraw your data now, please just close this browser. Otherwise, please select... Displayed

End of Block: non-user debrief

Start of Block: General App Info

Q2 **General Information**

Q41 Which Health Hub App do you use?

- ☐ Asthmahub for Parents
- ☐ Asthmahub
- ☐ COPDhub

Q3 How long have you been using the App?

- ○ Less than 1 month
- ○ 1-3 months
- ○ 4-6 months
- ○ More than 6 months

Q4 How often do you use the App?

- ○ Daily
- ○ Weekly
- ○ Monthly
- ○ As needed/when required

Q5 How did you hear about the App?

- ○ Healthcare professional
- ○ Online search
- ○ Friend or family
- ○ Other (please specify) _____

End of Block: General App Info

Start of Block: COM-B questions

Q6 **Your thoughts and feelings about the Health Hub App(s)** Thinking about your use of the App(s), please tell us how much you agree or disagree with each of the following statements. There are no right or wrong answers. For each statement, please select the response that most closely matches your thoughts and feelings about the App.

Q26 Using the App has helped me understand more about why it is important to manage my condition.

- ○ Strongly Agree
- ○ Agree
- ○ Neutral
- ○ Disagree
- ○ Strongly Disagree

Q35 I would recommend the App to others with respiratory conditions.

- ○ Strongly Agree
- ○ Agree
- ○ Neutral
- ○ Disagree
- ○ Strongly Disagree

Q34 Using the App has reduced my level of worry and anxiety about my condition.

- ○ Strongly Agree
- ○ Agree
- ○ Neutral
- ○ Disagree
- ○ Strongly Disagree

Q32 The App has empowered me to take control of my respiratory condition.

- ○ Strongly Agree
- ○ Agree
- ○ Neutral
- ○ Disagree
- ○ Strongly Disagree

Q31 The App has helped me understand how to manage my condition more effectively.

- ○ Strongly Agree
- ○ Agree
- ○ Neutral
- ○ Disagree
- ○ Strongly Disagree

Page Break

Q30 The App provides easy access to information that helps me self-manage my respiratory condition.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

Q29 I am more motivated to manage my condition since using the App.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

Q39 Has the use of your blue reliever inhaler changed since using the App?

- Yes - Increased
- Yes - decreased
- No - stayed the same
- Not sure

Q38 Since using the Respiratory App, my **unplanned** visits to healthcare services (e.g., GP, nurse, pharmacy) have:

- Increased
- Decreased
- Remained the same
- Not sure

Q37 Since using the App, I feel that my appointments with healthcare professionals (e.g., GP, nurse) have been more valuable.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

Page Break

Q36 I am NOT satisfied with the overall experience of using the App.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

Q19 If you would like to tell us more about how the App has helped/not helped you manage your condition please do so in the space below.

_____

End of Block: COM-B questions

Start of Block: SUS Scale

Q20 **Using the Health Hub App** We would now like you to answer some questions about how easy and user-friendly the App is.

SUS1 I think that I would like to use the App frequently.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Q2 SUS I found the App unnecessarily complex.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Q3 SUS I thought the App was easy to use.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Q4 SUS I think that I would need the support of a technical person to be able to use the App.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Q5 SUS I found the various functions in the App were well integrated (The different features like tracking symptoms and providing educational resources, these functions work together seamlessly)

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Q6 SUS I thought there was too much inconsistency in the App (in term of design, layout, or functionality of the app).

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Q7 SUS I think that most people would learn to use the App very quickly.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Q8 SUS I found the App very awkward to use.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Q9 SUS I felt very confident using the App.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Q10 SUS I needed to learn a lot of things before I could get going with the App.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

End of Block: SUS Scale

Start of Block: UX scale

Q1 Look at each of the opposing terms below and without thinking too much about it rate how you feel about your experience interacting with the App. There is no "right" or "wrong" answer. Only your personal opinion counts!

	-3	-2	-1	0	1	2	3	
	1	2	3	4	5	6	7	
Obstructive	○	○	○	○	○	○	○	Supportive
Complicated	○	○	○	○	○	○	○	Easy
Inefficient	○	○	○	○	○	○	○	Efficient
Confusing	○	○	○	○	○	○	○	Clear
Boring	○	○	○	○	○	○	○	Exciting
Not interesting	○	○	○	○	○	○	○	Interesting
Conventional	○	○	○	○	○	○	○	Inventive
Usual	○	○	○	○	○	○	○	Leading edge

Q5 Please tell us which features you find most useful in the App?

_____

_____

_____

_____

_____

Q6 Finally, do you have any suggestions for improving the App?

_____

_____

_____

_____

_____

End of Block: UX scale

Start of Block: Interview

Q69 If you are willing to be contacted about also taking part in an interview about your experiences of using the App please type your email address in the box below. Please be assured your email will not be linked to your survey data.

_____

End of Block: Interview

Appendix 6: Healthhub Survey Poster English

Do you or your child have Asthma or COPD?

We want to hear from you

We're looking for patients living with respiratory conditions such as Asthma or COPD to help us evaluate a Mobile App designed to help patients manage their respiratory condition.

To take part in this evaluation you need to be:

- Aged 18 Years or Over
- Have a Respiratory condition (COPD, Asthma)
- Willing to Answer a short online survey

To take part all you need to do is scan the QR Code with your Smart Phone

All data collected will be anonymous, cannot be traced back to you, and will be stored securely in line with data protection regulations. A full information sheet can be found on the survey link

For more information on the Evaluation
Contact: tritech.hdd@wales.nhs.uk

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Appendix 7: Healthhub Survey Poster Welsh

Ydych chi neu'ch plentyn yn dioddef o Asma neu COPD?

Hoffem glywed oddi wrthych

Rydym yn chwilio am gleifion sy'n byw gyda chyflyrau anadlol fel Asma neu COPD i'n helpu i werthuso Ap Symudol sydd wedi'i gynllunio i helpu cleifion i reoli eu cyflwr anadlol.

I gymryd rhan yn y gwerthusiad hwn, mae angen i chi fod:

- Yn 18 oed neu'n hŷn
- Bod â chyflwr anadlol (COPD, Asma)
- Yn barod i ateb arolwg byr ar-lein

I gymryd rhan y cyfan sydd angen i chi ei wneud yw sganio'r Cod QR gyda'ch Ffôn clyfar

Bydd yr holl ddata a gesglir yn ddienw, ni ellir ei olrhain yn ôl atoch, a bydd yn cael ei storio'n ddiogel yn unol â rheoliadau diogelu data. Gellir dod o hyd i daflen wybodaeth lawn ar y ddolen arolwg

Am fwy o wybodaeth am y Gwerthusiad
Cyswllt: tritech.hdd@wales.nhs.uk

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Appendix 8: Healthhub Asthma Checker Questions

Question number	Question	Answer for good (tick)
1	Did you have an asthma annual review this month?	yes
2	Did you pick up your asthma prescription?	yes
3	How many times did you visit your GP for your Asthma?	0
4	How many times did you go to A&E for your Asthma?	0
5	How many times were you admitted to hospital for your Asthma?	0
6	Did you have a hospital out-patient appointment last month?	Question for reference- no ‘good or ‘bad’ result,
7	How many courses of prednisolone did you have?	0
8	On average, how many times are you using your reliever inhaler per week?	0, or 1-2
9	Does anyone in your household smoke?	No
10: RCP 1	Have you had difficulty sleeping because of your asthma symptoms?	Answering no to all results in a score of 0. A score of 0 is a ‘good’ result.
10: RCP 2	Have you had your usual asthma symptoms during the day?	
10: RCP 3	Has your asthma interfered with your usual activities?	

A ‘good’ result is 10/10 ticks

These ticks come from:

- 9 questions in the table above (excluding question 6)
- 1 additional tick earned by completing the checker

On the checker result screen, this additional tick appears as “I am keeping up to date with my asthma checker.”

Appendix 9: Healthhub COPD Checker Questions

Question number	Question	Answer for good (tick)
1	Did you have COPD annual review this month?	yes
2	Did you pick up your COPD prescription?	yes
3	Are you confident in your inhaler technique?	yes
4	Are you using your reliever inhaler daily, or more often than you would normally?	No, I am not using it every day, or more often than is normal for me
5	How many times did you visit your GP for your COPD?	0
6	How many times did you go to A&E for your COPD?	0
7	How many times were you admitted to hospital for your COPD?	0
8	How many courses of antibiotics did you have?	0
9	How many courses of prednisolone/ oral steroids did you have?	0
10	Do you smoke?	No
11	Do you vape?	No
12	How many times per week do you do moderate physical activity? This includes activity that increases our heart rate e.g. walking, gardening or going to the gym.	At least once a week

A ‘good’ result is 13/13 ticks

These ticks come from:

- 12 questions in the table above)
- 1 additional tick earned by completing the checker

On the checker result screen, this additional tick appears as “I am keeping up to date with my COPD checker.”

Appendix 10: Patient Semi-structured Interview Questions

Patient Interview Questions

Introduce self, explain the purpose and structure of the interview, explain that the interview will be recorded for transcription purposes but will not be linked to any identifiable information.

1. **Can you briefly introduce yourself and share your experience with asthma or COPD, and how long you've been using the Respiratory App?**
(Catches "What did they think?" and "What did they like about it?")

2. **How would you describe the overall design and layout of the app?**
Was it easy to navigate, or did you face any specific challenges or barriers?
(Catches "What did they think?" and "What didn't they like about it?" and "Barriers")

3. **Which features of the app do you use most frequently,**
and are there any features you rarely use? Why?
(Catches "What did they like about it?" and "What didn't they like about it?")

4. **How effective has the app been in helping you monitor your symptoms and medication?**
Have you noticed any improvements in managing your condition?
(Catches "What did they think?" and "What did they like about it?" and "Have they changed their inhaler use since using the app? If so in what way?" and "Have they needed different medical support since using the app i.e. have they been to the ED or their GP fewer/same/more times since using the app?")

5. **How satisfied are you with the app's performance and reliability?**
Have you experienced any technical issues, and how were they resolved:
(Catches "What did they like about it?" and "What didn't they like about it?")

6. **Is there anything else you'd like to add about your experience with the app, or any suggestions for how it could be improved?**
(Catches "What do they think could be improved?" and "Is there anything they'd like to add?")

Appendix 11: Datasheet template sent to GP practices for completion

COPD & Asthma Appointments 01 January 2020 to Present

	Scheduled						Unscheduled					
	2020	*2021*	*2022*	*2023*	*2024*	*Total*	*2020*	*2021*	*2022*	*2023*	*2024*	*Total*
Jan						0						0
Feb						0						0
Mar						0						0
April						0						0
May						0						0
Jun						0						0
July						0						0
Aug						0						0
Sep						0						0
Oct						0						0
Now						0						0
Dec						0						0
Total	0	0	0	0	0		0	0	0	0	0	

Search: current registers with COPD A/Review, Asthma A/Review/Asthma F/U

Search: current registers with COPD/Asthma, chest infection, Exacerbation, cough or wheeze

Appendix 12: Health Care Professional Survey

Staff Survey Questions for Evaluating the Respiratory Toolkit

Start of Block: Consent

Q1 **Evaluation of the Institute of Clinical Science and Technology (ICST) Respiratory Toolkit What is the purpose of the evaluation?** Tritech and UWTSD's Assistive Technologies Innovation Centre (ATIC) are carrying out a service evaluation of the ICST Respiratory Toolkit. We are seeking respiratory health care professionals across Wales to help us evaluate the Toolkit. We want to find out if you have used any of the different elements of the respiratory toolkit, if you recommend the Healthhub apps to your patients, and if you believe it has had a positive or negative impact on your practice. To do this we need respiratory healthcare professionals who have used the Respiratory Toolkit to complete this short survey. **What happens if I agree to take part?** Taking part is voluntary. You will be asked to answer some questions about what you think about the Respiratory Toolkit which should take no longer than 5 minutes of your time. You can change your mind about participating at any point during the survey by simply closing your browser. **What happens to the information I give you?** All data collected will be anonymous, cannot be traced back to you, and will be stored securely in line with data protection regulations. For further information please read this information sheet. If you have any questions, please feel free to contact Dr Gareth Davies at gareth.davies14@wales.nhs.uk

Q2 By clicking on the "I Agree" button below, you acknowledge that you have read and understood this information sheet and agree to participate in the online survey.

- I Agree
- I Don't Agree

Skip To: End of Survey If By clicking on the "I Agree" button below, you acknowledge that you have read and understood this... = I Don't Agree

End of Block: Consent

Start of Block: Demographics block

Q3 Please select your gender

- Male
- Female
- Non-binary / third gender
- Prefer not to say

Q4 Please enter your age:

_____

Q5 Where do you work in Wales?

- Blaenau Gwent _____
- Bridgend
- Caerphilly
- Cardiff
- Carmarthenshire
- Ceredigion
- Conwy
- Denbighshire
- Flintshire
- Gwynedd
- Isle of Anglesey _____
- Merthyr Tydfil
- Monmouthshire
- Neath Port Talbot
- Newport
- Pembrokeshire
- Powys
- Rhondda Cynon Taff
- Swansea
- Torfaen
- Vale of Glamorgan
- Wrexham

Q7 What is your ethnic group? Please choose one option that best describes your ethnic group or background.

- White/White British
- Mixed/Multiple Ethnicity
- Asian/Asian British
- Black/African/Caribbean/Black British
- Any other ethnic group (please describe) _____

Q48 Which area do you work in?

- Primary Care
- Secondary Care
- Tertiary Care

Q49 What best describes your role?

- Respiratory Physician
- Respiratory Nurse Specialist
- Physiotherapist
- Respiratory Physiologist
- Other (please state) _____

End of Block: Demographics block

Start of Block: TriTech: Health Hub Apps - Part 1

Q11 Do you encourage your patients to manage their condition via the Health Hub Apps (COPDhub, Asthmahub and Asthmahub for Parents)?

- ○ No
- ○ Yes (please specify type of patients)

_____

Display This Question:

If Do you encourage your patients to manage their condition via the Health Hub Apps (COPDHub, Asthma... = No

Q45 If no, why not?

_____

End of Block: TriTech: Health Hub Apps - Part 1

Start of Block: TriTech: Health Hub Apps - Part 2

Display This Question:

If ?Yes,do you encourage your patients to manage their condition via the Health Hub Apps (COPDHub, Asthma... = Yes (please specify type of patients)

Q13 The Health Hub Apps enable me to get more out of my consultations with patients.

- ○ Strongly Agree
- ○ Agree
- ○ Neutral
- ○ Disagree
- ○ Strongly Disagree

Display This Question:

If you do encourage your patients to manage their condition via the Health Hub Apps (COPDHub, Asthma... = Yes (please specify type of patients)

Q23 I believe the Health Hub Apps have helped my patients to manage their condition more effectively.

- ○ Strongly Agree
- ○ Agree
- ○ Neutral
- ○ Disagree
- ○ Strongly Disagree

End of Block: TriTech: Health Hub Apps - Part 2

Start of Block: Tritech: Respiratory Toolkit platform

Q8 Have you used the All Wales ICST platform?

- ○ Yes
- ○ No

Display This Question:

If have you used the All Wales ICST platform? = No

Q40 If no, please specify the reason why:

_____

_____

_____

_____

_____

End of Block: Tritech: Respiratory Toolkit platform

Start of Block: Tritech: Respiratory Toolkit dashboard

Display This Question:

If have you used the All Wales ICST platform? = Yes

Q44 To what extent do you use the platform to stay up to date with associated respiratory condition guidelines?

- ○ To a great extent
- ○ To a large extent
- ○ Somewhat
- ○ Little
- ○ Not at all

Q9 How frequently do you use the platform?

- ○ Daily
- ○ Weekly
- ○ Monthly
- ○ As needed

Q10 To what extent do you see the platform positively impacting the way you practice?

- ○ To a great extent
- ○ To a large extent
- ○ Somewhat
- ○ Little
- ○ Not at all

Q50 How valuable do you find each of the component parts of the All Wales Platform?

	Very Valuable	Somewhat valuable	Neutral	Not very valuable	Not at all valuable
Education	○	○	○	○	○
All Wales Guidelines	○	○	○	○	○
Events	○	○	○	○	○
Emails	○	○	○	○	○
QI Projects	○	○	○	○	○
Assessments/Certificates	○	○	○	○	○

Q51 If you would like to expand on any of the answers above, please do so here.

_____

Display This Question:

If to what extent do you see the platform positively impacting the way you practice? = To a large extent

And to what extent do you see the platform positively impacting the way you practice? = To a great extent

Q41 Please specify how the platform positively impacted the way you practice:

_____

Q14 The platform is missing features that would improve my workflow.

- ○ Strongly disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly agree

Display This Question:

If The platform is missing features that would improve my workflow. = Agree

And The platform is missing features that would improve my workflow. = Strongly agree

Q15 If you agree, please specify the missing features:

_____

_____

_____

_____

Q16 The training provided for using the platform was adequate.

- ○ Strongly Agree
- ○ Agree
- ○ Neutral
- ○ Disagree
- ○ Strongly Disagree

Q17 The support resources (e.g., user manuals, help desk) are helpful in resolving issues with the platform.

- ○ Strongly Agree
- ○ Agree
- ○ Neutral
- ○ Disagree
- ○ Strongly Disagree
- ○ N/A I have never needed to access support resources

Q18 The platform integrates well into my daily workflow.

- ○ Strongly Agree
- ○ Agree
- ○ Neutral
- ○ Disagree
- ○ Strongly Disagree

Q19 I often experience technical issues with the platform.

- ○ Strongly Agree
- ○ Agree
- ○ Neutral
- ○ Disagree
- ○ Strongly Disagree

Display This Question:

If I often experience technical issues with the platform. = Disagree

And I often experience technical issues with the platform. = Strongly Disagree

Q20 If you agree, please specify the technical issues:

_____

_____

_____

_____

_____

Q21 There are significant barriers to using the platform effectively in my practice.

- ○ Strongly Agree
- ○ Agree
- ○ Neutral
- ○ Disagree
- ○ Strongly Disagree

Display This Question:

If There are significant barriers to using the platform effectively in my practice. = Disagree

And There are significant barriers to using the platform effectively in my practice. = Strongly Disagree

Q22 If you agree, please specify the barriers:

_____

_____

_____

_____

_____

Display This Question:

If I believe the Health Hub Apps have helped my patients to manage their condition more effectively. = Disagree

And I believe the Health Hub Apps have helped my patients to manage their condition more effectively. = Strongly Disagree

Q24 If you agree, please specify the patient outcomes (e.g., positive behaviour change, improved symptom management, increased adherence to treatment plans, etc.):

_____

_____

_____

_____

_____

Q25 Overall, I am satisfied with the platform.

- ○ Strongly Agree
- ○ Agree
- ○ Neutral
- ○ Disagree
- ○ Strongly Disagree

Q26 Would you recommend this platform to other Respiratory Clinicians, and professionals?

- ○ Yes
- ○ No

Display This Question:

If would you recommend this platform to other Respiratory Clinicians, and professionals? = No

Q42 If no, please specify why not:

_____

Q27, I have suggestions for the developers to improve the platform.

- No
- Yes

Display This Question:

If I have suggestions for the developers to improve the platform. = Yes

Q28 If yes, please specify your suggestions:

_____

_____

_____

_____

End of Block: Tritech: Respiratory Toolkit dashboard

Start of Block: Interview

Q47 If you are willing to be contacted about also taking part in an interview about your experiences of using the platform please type your email address in the box below. Please be assured your email will not be linked to your survey data.

_____

End of Block: Interview

Start of Block: SUS

Q46 In this final section, we will gather feedback to evaluate the usability of the platform and your experience with it.

Q29 I think that I would like to use the platform frequently.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Q30, I found the platform unnecessarily complex.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Q31 I thought the platform was easy to use.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Q32, I think that I would need the support of a technical person to be able to use the platform.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Q33 I found the various functions in the platform were well integrated.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Q34 I thought there was too much inconsistency in the platform (in term of design, layout, or functionality of the dashboard).

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Q35 I would imagine that most people would learn to use the platform very quickly.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strong Agree

Q36 I found the platform very cumbersome to use.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Q37 I felt very confident using the platform.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Q38 I needed to learn a lot of things before I could get going with the platform.

- ○ Strongly Disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly Agree

End of Block: SUS

Start of Block: UEQ

Q1 Look at each of the opposing terms below and without thinking too much about it rate how you feel about your experience interacting with the platform. There is no "right" or "wrong" answer. Only your personal opinion counts!

	-3	-2	-1	0	1	2	3	
	1	2	3	4	5	6	7	
Obstructive	○	○	○	○	○	○	○	Supportive
Complicated	○	○	○	○	○	○	○	Easy
Inefficient	○	○	○	○	○	○	○	Efficient
Confusing	○	○	○	○	○	○	○	Clear
Boring	○	○	○	○	○	○	○	Exciting
Not interesting	○	○	○	○	○	○	○	Interesting
Conventional	○	○	○	○	○	○	○	Inventive
Usual	○	○	○	○	○	○	○	Leading edge

End of Block: UEQ

Appendix 13: Health Care Professional Semi-structured Interview Questions

ICST Staff Interview Questions

Introduce self, explain the purpose and structure of the interview, explain that the interview will be recorded for transcription purposes but will not be linked to any identifiable information. Ask if there are any conflicts of interest to be declared

ALL WALES ICST PLATFORM

1. **Can you briefly introduce yourself and describe your role in patient care? Do you use the All Wales ICST Platform or other tools developed by ICST e.g. ICST guidelines?**
(Catches "What do they use it for?", "How long have they been using it?" and "How often do they use it?")

(If Yes)

2. **Has the platform or the ICST guidelines had an impact on the way that you practice?**
(Catches "How?", "What did they think about it?" an "What impact has it had?")

3. **Has this had any impact on patient outcomes?**
(Catches "What did they think?" and "What did they like about it?")

4. **How would you describe the overall design, layout, and ease of navigation of the All Wales ICST Platform?**
(Catches "What did they think?" and "What didn't they like about it?")

5. **Were there any specific areas where you experienced difficulties or found barriers in using the platform or guidelines?**
(Catches "What did they think?" and "What didn't they like about it?" and "Barriers")

(If No)

6. **Why don't you use the platform or guidelines?**
(Catches "Have they used it at all?" and "What didn't they like about it?" and "Barriers")

ALL WALES ICST PLATFORM

7. **Do you encourage your COPD and asthma patients to use the Health Hub applications (COPDHub, asthmaHub and asthmaHub for parents)?**
(Catches "How long have they been promoting the applications?" and "How is uptake?")

(If Yes)

8. **Have the Health Hub applications had an impact on the way you interact with patients? Have the applications had an effect your consultations with the patients that use them?**
(Catches "What did they think?" and "What did they like about it?")

9. **Do you think the Health Hub applications are effective in helping individuals with COPD and asthma to manage their condition? Have you noticed any changes in behaviour such as inhaler usage that could be attributed to the applications? Have you noticed an impact on patient outcomes?**
(Catches "What did they think?" and "What did they like about it?")

(If No)

10. **Why don't you use the platform or guidelines?**
(Catches "What didn't they like about it?" and "Barriers")

BOTH PLATFORM AND PATIENT FACING APPLICATIONS

11. **Is there anything you'd like to add or suggest to improve the ICST Platform or Health Hub Applications? What features would better support your work with asthma or COPD patients?**
(Catches "What do they think could be improved?" and "Is there anything they'd like to add?")

12. **Would you recommend the All Wales ICST Platform, guidelines and Health Hub applications to other health care professionals?**
(Catches "What did they like about it?" and "What didn't they like about it?")
(Catches "Would they recommend all three?" "Do they think there is more value in certain elements of the toolkit?")

Appendix 14: Commissioner Semi-structured Interview Questions

ICST Commissioner Interview Questions

Introduce self, explain the purpose and structure of the interview, explain that the interview will be recorded for transcription purposes but will not be linked to any identifiable information. Ask if there are any conflicts of interest to be declared.

ALL WALES ICST RESPIRATORY TOOLKIT

1. **Can you briefly introduce yourself and describe your role in commissioning the ICST toolkit?**
(Catches "What do they use it for?", "How long have they been using it?" and "How often do they use it?")

2. **Do you review or engage with the information provided by ICST through the various reports and through the commissioner's dashboard?**
(Catches "Do they review the information in e-mails?", "Do they use the commissioner's dashboard?", "What do they think of it?", "If not, why not?")

3. **Are you happy with the medium and frequency that information is provided?**
(Catches "Would they like information more/less frequently?", "What is their preferable way for receiving information? i.e. do they prefer to view information through the dashboard, do they prefer e-mails?")

4. **Do you feel that the information provided by ICST has been useful in guiding commissioning decisions?**
(Catches "What did they think about the information provided?" and "Is it presented in a way that is easy to interpret?")

5. **Do you think there is additional information that could be provided that would be valuable in guiding commissioning decisions?**
(Catches "Are there other useful metrics they would like to see provided?" "Would they like to see more data on deprivation, clinical data, inhaler use? Etc.)

Appendix 15: List of Awards Won by The ICST Respiratory Toolkit

- Environmental Sustainability Project of the Year, Gold Winner (HSJ Partnership Awards, 2024).
- Moving Towards Net Zero Through Digital, Winner (HSJ Digital Awards, 2023).
- Generating Impact in Population Health Through Digital (HSJ Digital Awards, 2023).
- Digital Patient Transformation Award, Winner (HTN Now Awards, 2024).
- Best Solution to Manage Chronic Disease, Winner (Health Tech Digital Awards, 2024).
- Best Innovation Project of the Year, Winner (Health Tech Digital Awards, 2024).
- Scaling up Innovation and Transformation Award, Winner (Mediwales Innovation Awards, 2024).

Appendix 16: ORCHA Review Summary

ORCHA:

Founded in the UK by NHS clinicians, ORCHA's mission is to "put the power of digital health safely into the hands of everyone who needs it".

The partner with numerous organisations, including NHS England, NICE, CQC, MHRA, the

Dutch Foundation for Mental Health, the American College of Physicians, the American Telemedicine Association, Boehringer Ingelheim and Bayer. They also work with health and care providers in 70% of NHS regions.

ORCHA score the apps based on the OBR (ORCHA Baseline Review), which has been designed to cover over 350 review points used within 70% of global industry standards.

Some of these standards include:

CQC – Care Quality Commission	If an App provides a health service to the user, it may need to be registered with the CQC.
Caldicott Principles	They assess whether Apps comply with the NHS Data Standards. The Caldicott Principles ensure that any patient information which could identify them is protected, and is only used and shared when it is appropriate to do so.
DSPT – Data Security and Protection Toolkit	They assess whether Apps comply with the NHS Data Standards.
ESF – Evidence Standards Framework	Guidelines published by NICE used to measure the effectiveness or impact of Apps.
GDPR/DPA 2018 – General Data Protection Regulation/ Data Protection Act 2018.	They assess whether an App is fully compliant with GDPR and follows the correct data protection guidelines.
ISO 13485	Quality management system for medical devices
ISO 14971	Application of risk management to medical devices.

ISO 27001	An International Data Management Standard, specifically concerning information security management.
ISO 9241	App design standards
MDR – Medical Device Regulations (successor to MDD – Medical Device Directive)	The European Union Medical Device
MHRA – Medicines and Healthcare products Regulatory Authority	The European Union Medical Device Regulations replaces the existing Medical Device Directive in May 2020. Products which display features or make claims which may pertain to be a medical device should have a CE mark. The MDR makes sure that such devices are safe and effective for public use.
NICE – The National Institute for Health and Care Excellence	NICE provide guidance, advice and information services for health, public health and social care professionals. NICE published the ESF guidance to measure the effectiveness or impact of Apps.
WCAG 2.0 AA/WCAG 2.1 AA – Web Content Accessibility Guidelines 2.0 and 2.1	ORCHA establish whether an App has been designed and developed according to the appropriate App design standards.

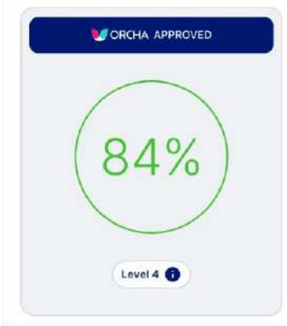
Overall, the apps are looked at in terms of their:

Data and privacy
Professional assurance and clinical safety
Clinical outcomes
Usability and accessibility
Interoperability
Technical security and stability

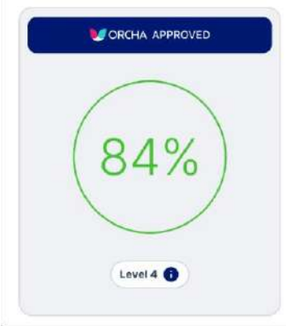
Respiratory apps scoring:

All of the ICST respiratory apps scored 84% when assessed against the ORCHA OBR. ORCHA classes a 'good' app as those who score 65% or above.

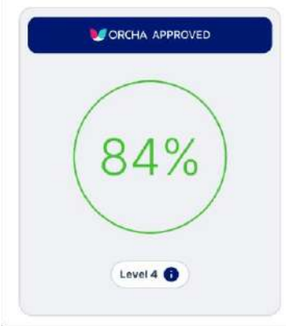
COPDhub



Asthmahub



Asthmahub for Parents



ORCHA has developed an App Classification System which categorises apps in one of 4 levels (1-4), based on their area of focus and their functional capabilities. The more health focused and functionally rich an app is, the higher its level, and the more areas of investigation ORCHA uses when assessing it. This means it is more difficult for apps of a higher level to score highly.

Very simple wellbeing-focused apps (typically level 1) are not, for example, assessed based on their clinical assurance, because they do not deliver a clinical solution. Level 4 apps are at the top end in terms of focus and functionality and are required to establish compliance with other regulatory environments such as medical device regulations.

Level 1 – Well-being/ Utility

Level 2 – General Health

Level 3 – Condition Management

These apps can be focused on general health or supporting specific health conditions.

Level 4 – Regulated

These apps can be focused on general health or specific conditions and contain advanced and complex features that are subject to formal regulation.

Appendix 17: Critical review of literature - Effectiveness of digital health technology in managing chronic obstructive pulmonary disease (COPD) : A patient and service perspective

Critical review of literature - Effectiveness of digital health technology in managing chronic obstructive pulmonary disease (COPD): A patient and service perspective

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SHQM22: Dissertation - MSc Health Care Management

Dr David Rea

August 31, 2024

Exact Word Count: 9,000

DECLARATIONS AND STATEMENTS

Declaration

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Signed: Balage Kalana Randula De Silva Date: 31.08.2023

Statement 1

This work is the result of my own independent study/investigation, except where otherwise stated. Other sources are acknowledged by footnotes giving explicit references. A bibliography is appended.

Signed: Balage Kalana Randula De Silva Date: 31.08.2023

Statement 2

I hereby give my consent for my work, if relevant and accepted, to be available for photocopying and for inter-library loan, and for the title and summary to be made available to outside organisations.

Signed: Balage Kalana Randula De Silva Date: 31.08.2023

ACKNOWLEDGEMENTS

I would like to extend my sincere gratitude to my supervisor, DrDavid Rea, for his unwavering support and guidance throughout the completion of this study. I would also like to express my heartfelt thanks to my family for their unwavering support and encouragement throughout this journey.

ABSTRACT

BACKGROUND

The development of chronic medical conditions within the UK and worldwide has been steadily increasing. Of the many reasons that contributed to the development of chronic medical conditions lifestyle and longevity of life are two key components. As there are factors which are difficult to change there is an ever-increasing rise of chronic medical conditions such as chronic obstructive pulmonary disease (COPD). These conditions can place a huge stain on health services as demand for healthcare rises. Novel digital health technology (DHT) has been posed as a potential solution to the burden placed on chronic medical conditions.

AIM

This study aims to evaluate if DHT can positively impact healthcare services for COPD. This will be done by exploring currently tested DHT devices, exploring the impact of these devices on patient and service outcomes and finally by looking at cost-effectiveness.

METHODOLOGY

This study uses a native approach to a critical review of the literature (CLR) to answer the research question. A database search using PubMed, SCOPUS and Cochrane CENTRAL was used to find relevant randomised control trials. Of the 302 articles found in the search, 12 were studied in this CLR.

RESULTS

This CLR found mixed evidence in support of the use of digital health technologies. Importantly, though the results were mixed it did not suggest that DHT was harmful or worsened current standard COPD care.

CONCLUSION

DHT has the potential to be instrumental in future health and care services, however, the mixed picture of results suggests that the technology needs further research and advancement. Likewise, healthcare services need to evolve to be able to effectively incorporate these new tools within their services.

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INTRODUCTION

BACKGROUND

Healthcare, both globally and within the United Kingdom (UK), is increasingly strained by rising demand and diminishing resources. In addition to this, there is significant global interest in leveraging digital solutions as tools to improve the quality and safety of healthcare. Digital health (DH) could reshape the way we deliver healthcare in the future. Research within healthcare delivery and organisation forecasts unprecedented obstacles due to the complexity and novelty of the DH. As a result, Bravata et al. (2005) describes a three-step approach for high-quality evidence synthesis within this domain: conceptual framework, systematic searching and hybrid synthesis, to ensure informed decision-making. Building on the work of Bravata et al. (2005), this chapter delves into a comprehensive analysis of the impact of chronic non-communicable diseases (NCDs) on healthcare systems at a systemic level. We begin by defining NCDs. Next, we will focus on chronic obstructive pulmonary disease (COPD) a respiratory NCD, briefly exploring its aetiology, epidemiology, clinical presentation, investigations, management, mortality, and prognosis. Finally, exploring how digital health (DH), in the shape of digital technologies (DHTs) could present an opportunity to advance COPD management.

Impact of Chronic Non-Communicable Diseases

The prevalence of NCD is a growing concern for healthcare and public health services globally (Davies et al., 2014; Hanlon et al., 2011). Despite, being an imminent threat to many economies, the literature is conflicted on the most appropriate terminology (Bernell & Howard, 2016). The World Health Organization (2023c) suggests that NCDs are chronic diseases characterised by complex and multifactorial aetiologies. Ackland et al. (2003) importantly distinguished the difference between chronic communicable diseases such as HIV and chronic non-communicable diseases such as COPD. They go on to argue that non-communicable diseases are communicable, however not in the conventional form, but through psycho-social, cultural and ethnic vectors. Unwin et al. (2004) concluded by suggesting that the term transmissible chronic diseases be used to categorise long-term health conditions to ensure precision in policymaking. This term, however, creates confusion between infectious and non-infectious chronic diseases. For the purposes of this

study, NCDs are persistent, long-term, non-infectious health conditions resulting from a combination of genetic, physiological, behavioural and environmental factors.

Rising chronic NCDs have lasting impacts on the individual and the economy. A UK Labor Force Survey from 2023 indicates a significant rise in self-reported chronic NCD of working-age adults. 36% of these individuals reported at least one chronic medical condition in the first quarter of 2023, compared to 31% in 2019 and 29% in 2016 in the same quarter (Office for National Statistics, 2023a). The statistic presents a broad view of chronic NCDs in the UK, accounting for conditions such as depression, mental health, musculoskeletal, cardiovascular, respiratory and digestive maladies, highlighting the alarmingly upward trajectory at which chronic NCDs are impacting the British population. Evidence suggests that chronic NCDs negatively impact patient's physical and emotional well-being. Benkel et al. (2020) found that patients living with an NCD are constantly clouded by negative emotions. They found that positive support from family and healthcare professionals was reported as valuable by patients, however, the study did not evaluate how this support should be delivered. A qualitative study from Van Wilder et al. (2021) found that patients from a lower socioeconomic status (SES) were at higher risk of negative health outcomes due to added financial burden and lack of family/social support. They found that due to poor support, individuals from lower SES were at higher risk of utilising maladaptive coping mechanisms which worsened health outcomes. Van Wilder et al. (2021) importantly outlines that patients with chronic NCDs may require personalised health care which connects individuals to different services

At an economic level, the Office for National Statistics (2023a) has identified over 2.5 million individuals, who are economically inactive due to work-limiting chronic health conditions, this figure has risen from 2 million in 2019. Moreover, the sickness absence rate for individuals in the workforce living with long-term health conditions has increased to 4.9% in 2022 (Office for National Statistics, 2023b). Suggesting that more individuals than ever before are out of work due to long-term health conditions, and those who are employed are taking more sick days due to their diagnoses.

COPD

Having discussed the complexities and impact of NCDs, this study now focuses on one chronic NCD, COPD. COPD is a heterogeneous, obstructive lung disease defined by progressive, irreversible airflow obstruction caused by inflammation of the airways and parenchyma (Buist, 2003). COPD can be considered an umbrella term for chronic bronchitis and emphysema. Aetiologically, genetic, developmental, environmental, and cultural factors increase the risk of COPD (Rabe & Watz, 2017). Exposure to inhaled tobacco smoke and air pollution are the two most common risk factors for COPD. Epidemiologically, the World Health Organization (2023a) estimates COPD is the third leading cause of death worldwide, with tobacco smoking accounting for nearly three-quarters of COPD cases in high-income countries

COPD characteristically presents with worsening breathlessness, productive cough, regular chest infections, and wheezing, additionally, patients may present with a myriad of systemic symptoms (National Institute for Health and Care Excellence, 2024). COPD patients can experience acute exacerbations. Exacerbations are a flare-up of worsening symptoms which can lead to hospitalisation (National Institute for Health and Care Excellence, 2024). Patients with COPD tend to be afflicted with other diseases including but not limited to cardiovascular disease, lung cancer, osteoporosis, muscle weakness and depression (Rabe & Watz, 2017).

Treating COPD, its exacerbations and comorbidities requires a complex, systematic and personalised approach. Firstly, and most importantly, in individuals who smoke, lifestyle advice on smoking cessation is necessary to reduce the progressive decline in lung function, reduce smoking-related comorbidities such as lung cancer and limit exacerbations (Rabe & Watz, 2017). Additionally, vaccinations, physical activity, pulmonary rehabilitation, and oral and inhaled pharmacotherapy all play vital roles in the development of a well-planned treatment plan for COPD patients (National Institute for Health and Care Excellence, 2024; Rabe & Watz, 2017).

Opportunity for Transformation

Having examined the individual and economic impacts of chronic NCDs such as COPD. This section of the introduction aims to look at opportunities which can transform

healthcare services in the UK to help the growing burden of chronic NCDs. Driven by the widespread use of mobile phones, DHTs could give individuals the power to manage their health, transforming the way healthcare systems work. DHTs such as patient-facing apps are potential solutions to rising healthcare demands caused by chronic NCDs.

What is a DHT?

The literature on DH is rapidly evolving, leading to a continually expanding array of definitions for DH and numerous variations in DHTs.

World Health Organization (2019) recognises eHealth and mobile health (mHealth) as two similar but distinct terms which are encompassed by the term DH. eHealth is the utilisation of information and communication technology to support health and health-related fields. mHealth is very similar to eHealth, though it's a specialist term for wireless mobile technologies used for public health. DH is an umbrella term that accounts for mHealth, eHealth, and novel areas of artificial intelligence (AI), big data and genomics. National Institute for Health and Care Excellence (2022) suggests that the term digital health technology (DHT) is used for any independent application or software (excluding those integrated into hardware in the form of medical devices) designed to enhance health outcomes or optimise the functioning of the healthcare system.

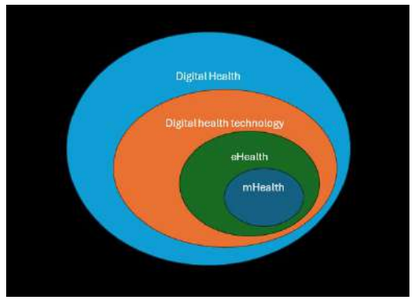


Figure 1. Diagram illustrating how novel terms of the field are interrelated.

History of digital health

The analogue, and sometimes outdated nature of face-to-face healthcare systems can expose it to external threats, this was showcased by the coronavirus pandemic (COVID-19). DH may allow for a new approach. Though DHT's use has become more mainstream since COVID-19, DH theories can be dated back to the early 1900s, with a vision to diagnose patients over the radio (Lustig, 2012). Likewise, in 1960 the National Aeronautics and Space Association (NASA) used a variant of DH to continuously track and monitor astronauts' health conditions during the Mercury space programme.

More recently, pressures exerted on healthcare systems by the COVID-19 pandemic have catalysed the development and adoption of innovative digital health solutions to healthcare. A systematic review of literature carried out by Golinelli et al. (2020) showcases different types of digital technologies that were used during COVID-19, they uncovered the use of innovations such as AI diagnostic tools, electronic health records, mobile phone apps and telehealth. Interestingly, their research concurred with the opinion of Keesara et al. (2020) that some of these technologies were available for many years but had not been implemented due to regulatory and payment barriers.

Use of digital health solutions in chronic noncommunicable diseases

Digital health monitoring of chronic diseases has become increasingly prevalent in recent years, with various studies highlighting its impact on different conditions (Liu et al., 2020; Thomas Craig et al., 2021). Digital health monitoring presents a unique opportunity to produce clinical benefits by giving patients more control of their health and assisting service providers in improving service provisions and outcomes (Enam et al., 2022; Morton et al., 2017).

Digital health monitoring devices could be utilised to manage and monitor an individual's respiratory condition. However, as this intervention is still in the early stages of implementation it is important to understand the extent, range and nature of the research surrounding digital health monitoring of chronic conditions. Research in this area could inform future COPD care.

Research Question and Research Objectives

This dissertation aims to evaluate the available DHT designed for COPD, assessing their impact on patient outcomes, service outcomes and cost-effectiveness. Through this evaluation, the study seeks to identify key features and best practices that contribute to the

success of these digital health interventions, providing insights that can inform future development and implementation of health technologies for chronic disease management.

This study seeks to address the following research question, can novel DHT developments positively impact COPD health and care services? This research question was developed upon a scoping search of the literature to confirm the feasibility and the PICO guidelines (Davies, 2011). The study aims to answer this question by exploring these research objectives. Firstly, understand the types and functions of different COPD DHTs. Secondly, to evaluate the impact of DHTs on patient outcomes. Thirdly, explore how service outcomes are affected by currently available DHT for COPD patients. Finally, by exploring the cost-effectiveness of research DHTs for COPD

Organisational Layout of the Study

This dissertation is a critical literature review, comprising four chapters. Each chapter is organised into sections and parts. A section evaluates different concepts/themes within a chapter. A part, similar to a section, evaluates different themes within a section.

Chapter 1 was an introduction to the topic of chronic NCD, COPD and DHT. Chapter 1 so introduced the research question and objectives, which will act as the backbone of the rest of the study.

Chapter 2 is the methodology; this section of this dissertation explores the research approach and is systematically detailed to ensure clarity and rigour in the study. This section is divided into two main parts: the Literature Search and the Data Screening Process and Studies Selected. This structured approach provides a clear conceptualisation of how the research was conducted and how the relevant literature was chosen for review.

Chapter 3, the results of this study. Has been organized to provide a comprehensive understanding of the role and impact of DHT within the context of COPD care. The chapter is divided into four key areas. First, it examines the various types of DHT identified in the selected randomized controlled trials (RCTs), highlighting the diversity of technologies utilized in patient care. Second, it evaluates the impact of DHT on patient outcomes, focusing on health and physiological status, patient experience, and overall satisfaction. Third, it explores the effects of DHT on healthcare service outcomes, including efficiency, effectiveness, and accessibility. Lastly, the section delves into the economic analyses presented in the literature, offering insights into the cost-effectiveness and financial implications of DHT implementation in COPD care.

Methodology

Having previously conceptualised the development of digital health (DH) within the context of COPD care and formulating a research question using the PICO framework, this chapter aims to describe the literature identification process for this study. Ethical approval was not required for this study.

Search Strategy

As described in the introduction this study aims to evaluate the effectiveness of DHT in helping individuals with COPD manage their conditions. A narrative-based critical literature review (CLR) approach was decided for this study, as it has the potential to produce broader insights into an area of research (Rodgers et al., 2009). Grant and Booth (2009) suggest that the strength of a CLR is derived from its innate ability to assess the value of previous work through the mediums of extensive research and critical evaluation. However, they outline that CLRs lack the structured systematic approach of other literature review approaches. Where possible, whilst appreciating inherent limitations, this review adheres to previously described best practices to compensate for CLR's unsystematic nature (Atkinson & Cipriani, 2018; Bramer et al., 2017). Additionally, the heterogeneity within the literature made it impossible to conduct a quantitative analysis.

The literature recommends the use of two or more databases with varying scopes for a comprehensive search, therefore, this CLR will search Cochrane CENTRAL, PubMed and Scopus for literature (Bramer et al., 2017; Suarez-Almazor et al., 2000). Cochrane CENTRAL provides a health-specific database focusing on research trials. PubMed provides an additional health-specific database. Cochrane CENTRAL and PubMed both focus on healthcare-specific literature, with Cochrane CENTRAL offering more research trial data. SCOPUS was chosen as a non-health-specific database to provide a wider scope of literature. Within the limited bounds of this study, these three databases allow for a diverse range of

searches. It has been noted that the lack of grey literature and inherent limitations of SCOPUS increase the opportunity for publication bias (Paez, 2017).

The following sections of this chapter will provide a detailed explanation of the five-step process utilized in the CLR for the literature search. This process was developed based on the methodology outlined by (Aromataris & Riitano, 2014).

5-step search process

1. Identifying search terms required a stepwise, iterative approach (Bravata et al., 2005). Three key search concepts were identified from the PICO analysis and research question. 'Patient facing applications', 'COPD' and ' Manage health'. As the concept of 'Outcomes' (as outlined by the PICO framework) is often less clearly defined in research titles and abstracts, it was excluded from the search strategy (Atkinson & Cipriani, 2018). Utilising the previously developed in-debt exploration of the research area, the search concepts were populated with keywords and synonyms of these words.
2. Once a comprehensive list of free text terms had been selected, these terms were used to identify key Medical Subject Headings (MeSH) terms using PubMed's MeSH builder. Next, the free text terms were developed using phrase searching, truncation and proximity operators to ensure maximum efficiency.
3. At this stage it is necessary to outline that database dependant variation was observed within the search terms and search syntax. To ensure appropriateness, database-specific guidelines were used to refine individual searches (appendix 1).
4. Search filters were applied to refine the literature search while ensuring the evidence remained relevant to this CLR. Searches were limited between 2014 and 2024, articles and research trials, and English language. Additionally, studies were included in this CLR if they were carried out in healthcare systems comparable to the NHS. This included: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Portugal, Spain, Sweden and the USA (Dayan et al., 2018). SCOPUS was the only database which had limiters on country of origin, database-specific search limits can be found in (appendix 1). These limits were adequate to understand shifts in the subject area, whilst maintaining a manageable number of articles.
5. A pilot search was conducted to identify and address any potential issues before performing the final search. The learnings of the pilot search were used to define the final search. The results of the final search were then screened using predefined inclusion and exclusion criteria until studies used in this review were identified. The results of the final search, after literature exclusion can be found in appendix 2.

Table 1.

Key concepts, along with their free text and controlled vocabulary terms used in the literature search.

	Concept 1	Concept 2	Concept 3
Key concepts	Patient facing applications	Asthma and COPD	Manage health
Free text terms / natural language terms	Digital health* (Digital health/ Digital health monitoring/ Digital health technology) Virtual health* (Virtual health care / Virtual health technology) Digital therapies Digital interventions Mobile health Telehealth Telemedicine eHealth mhealth	COPD* Chronic obstructive pulmonary disease * Bronchitis* Emphysema*	Self-monitoring Self-management Remote monitoring Outpatient monitoring Home monitoring
Controlled vocabulary terms / Subject terms	((("Digital Health"[Mesh]) AND ""Telemedicine"[Mesh:NoExp]) AND "Distance Counseling"[Mesh]) AND "Remote Consultation"[Mesh:NoExp]))	((("Pulmonary Disease, Chronic Obstructive"[Mesh:NoExp]) AND "Asthma-Chronic Obstructive Pulmonary Disease Overlap Syndrome"[Mesh]) AND "Bronchitis, Chronic"[Mesh]) AND "Pulmonary Emphysema"[Mesh]	(("Self-Management"[Mesh]) AND "Monitoring, Ambulatory"[Mesh:NoExp]) AND "Monitoring, Physiologic"[Mesh:NoExp]) AND "Self Care"[Mesh:NoExp]

Inclusion and Exclusion Criteria

Publications were only included in the analysis if they met predefined inclusion and exclusion criteria. Table 2. details the criteria used to select randomized controlled trials (RCTs) for this review,

Table 2.

Inclusion and exclusion criteria for the CLR.

Criteria	Inclusion	Exclusion
Population	Studies which focused on COPD patients or COPD as a comorbidity	Any other medical conditions
Intervention type	DHT which involved remote self-monitoring	Any other DHT type or invention is not a DHT

Study design	Randomised control trials	Literature and systematic review Cohort studies Case-control studies Cross-sectional studies Expert opinion Pilot/ feasibility trial Proof of concept Grey literature
Country of origin	Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Portugal, Spain, Sweden, UK and the USA	Any other country
Text type	Full text accessible online	Full text unavailable

Data Screening Process and Studies Selected

Following the descriptions of the search strategy and publication eligibility criteria, the subsequent sections of this chapter will define the data screening process, present the studies selected for this CLR and summarise the methodology using a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRIMSA) flow diagram.

Data Screening

The study selection process was structured around the recommendations of Levac et al. (2010). Utilising a narrative approach, studies were initially excluded based on their title and abstracts, then a full-text analysis. During the title and abstract assessment stage, articles were excluded based on population group, type of DHT, country of origin, research methods, and research objectives that did not align with this CLR's PICO framework. During full-text analysis, studies were excluded due to the unavailability of full texts, undesirable study PICO objectives and the presence of duplicates.

RCTs which met the inclusion criteria for full-text analysis were appraised for quality based on potential risk/bias and transparency using the Critical Appraisal Skills Programme (CASP) framework (Critical Appraisal Skills Programme, 2021). Although CASP is not typically recommended for scoring, this review has utilised a CASP-based scoring system to examine the quality of the studies, following the systematic approach employed by Black et al. (2011). This scoring system is not a comprehensive, quantitative assessment of RCT quality, but rather a tool to illustrate each study's potential biases.

Studies Selected

Out of the 302 studies which were identified during the literature search, only 22 were critically appraised using CASP. Critical Appraisal Skills Programme (2021) Framework consists of 11 questions categorised to evaluate a study's design, methodology, results and applicability. In this CLR, each question was scored on a scale of 0 to 3. Based on the CASP framework and Black et al. (2011), a higher overall score indicates that an RCT is more transparent, with a lower risk of bias, classifying it as a higher quality.

To ensure that only the highest quality publications were included in the CLR, a cutoff score of 27 was applied. Table 3 summarises each paper based on its relation to CASP's randomised control trial checklist.

Table 3.

Final 12 studies selected for appraisal and synthesis using CASP framework.

Author, year	Year	Section A		Section B		Section C			Section D			Results
Y:3,SW:2,N:1,CT:0		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	
Mínguez Clemente et al., 2021	2021	3	3	3	0	3	3	3	3	3	3	3	30
Ritchie et al., 2016	2016	3	3	3	2	3	3	3	3	2	2	2	29
Farmer et al., 2017	2017	3	3	3	1	2	3	3	3	2	3	3	29
Walker et al., 2018	2018	3	3	3	1	3	2	3	3	3	3	2	29
Zanaboni et al., 2023	2023	3	3	3	2	3	3	3	3	2	2	2	29
Koff et al., 2020	2020	3	2	3	0	3	2	3	3	3	3	3	28
Lear et al., 2021	2021	3	3	3	2	3	2	3	3	2	2	2	28
McDowell et al., 2015	2015	3	3	3	1	3	2	3	1	3	3	2	27
Jakobsen et al., 2015	2015	3	3	3	1	3	3	3	3	1	2	2	27
Ringbæk et al., 2015	2015	3	3	3	0	3	3	3	2	2	3	2	27
Tupper et al., 2018	2018	3	3	3	0	3	3	2	3	2	3	2	27
(Loeckx et al., 2023)	2023	3	3	3	1	3	3	3	3	2	2	1	27

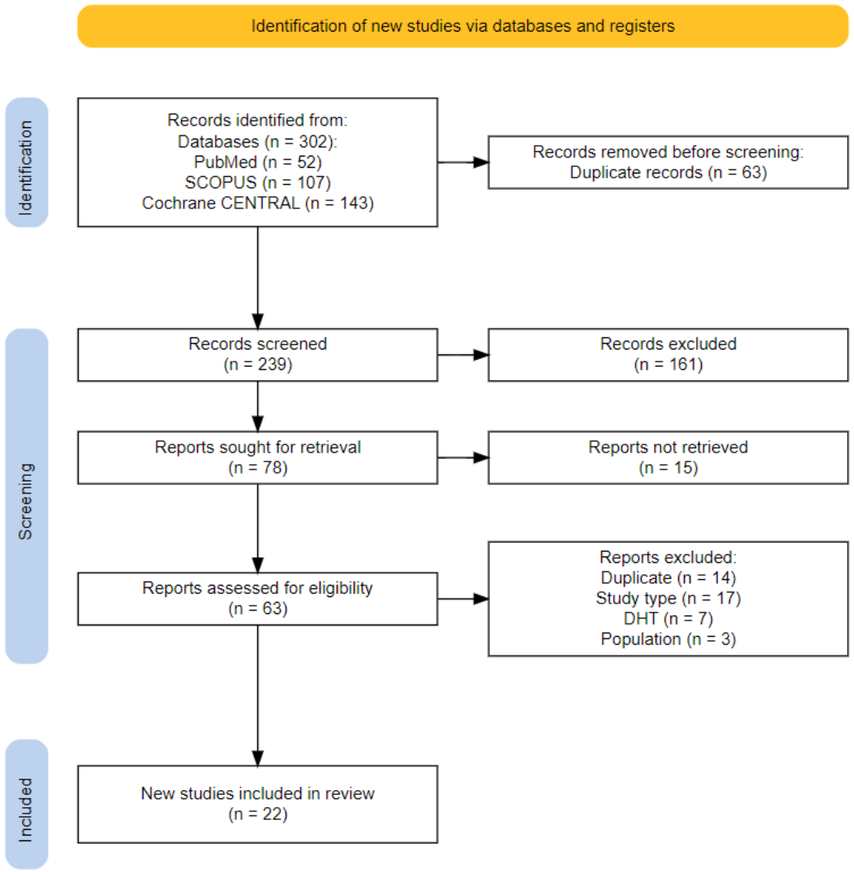
The scoring system uses a 3-point system. If the answer to a question is yes then it receives 3 points. If the answer explores some but not all of the questions (somewhat) it receives 2 points. If the answer states that the question was not answered it receives 1 point. If the question has not been discussed (cannot tell), then it receives 0 points.

PRISMA

The study selection process, inclusion and exclusion criteria have been summarised in Figure 1 using a PRISMA flow diagram (Haddaway et al., 2022).

Figure 2.

PRISMA flow diagram summarising the search and data selection process of this CLR.



RESULTS

The results section of this dissertation builds upon the understanding of the search methodology and the selected literature, aiming to critically evaluate and analyse the findings. This section is divided into three sections. Section one, the Appraisal, develops on elements of the CASP framework, examining the varying study designs within the literature, and evaluating if this may influence the overall outcomes and validity of the research. In section two, the Synthesis, a critical analysis of the different outcomes, results and conclusion from the selected RCTs is conducted, offering insights into the collective findings and their implications. Finally, section three examines and evaluates any limitations of the RCTs used in this CLR.

The search retrieved a total of 22 references, of which 12 RCTs were selected for inclusion. The final 12 RCTs provided the main empirical evidence base in assessing the impact of DHT on COPD services. In this section, "literature" refers to the RCTs included in the CLR.

APPRAISAL

As previously mentioned, this section of the results chapters, which is divided into two parts, aims to critically evaluate the characteristics of the final 12 RCTs. Firstly, we will examine the study designs by assessing the population, intervention, comparator and outcomes of RCTs. Next, this CLR aims to analyse the properties of each methodology. This appraisal identifies the strengths and weaknesses of each study, impacting on how the results are interpreted and applied.

Study Design

The selected RCTs provide an international perspective of remote health monitoring using DHT. The literature has been developed within the United Kingdom, the United States of America, Canada, Spain, Belgium and Denmark. Two RCT protocols were developed to be multinational, recruiting participants from more than 2 countries (Walker et al., 2018; P. Zanaboni et al., 2023).

As showcased in table 3 all RCTs in this CLR have to some extent met the criteria for a valid study design. The literature's main focus is COPD, however, study designs did sometimes expand their inclusion criteria to evaluate how remote monitoring using DHT impacted individuals with other chronic medical conditions (Lear et al., 2021; Ritchie et al., 2016; Walker et al., 2018). Other chronic NCDs include chronic health failure (Litchfield et

al.), ischemic heart disease (IHD), hypertension, hyperlipidaemia, and sleep-disordered breathing.

Interestingly, the literature had varying inclusion criteria for COPD severity and participant age. Most study protocols only included COPD patients who were categorised as severe to very severe (defined as GOLD grade 2 or higher) or recruited individuals without a criterion for COPD severity. Only McDowell et al. (2015) recruited individuals with moderate to severe COPD (GOLD grade 1-2). The majority of RCTs, appropriately, did not include an age criterion during patient recruitment. However, Farmer et al. (2017) and Jakobsen et al. (2015) limited patients to 40 and over, whilst Walker et al. (2018) limited study design to patients 60 and over.

This body of literature has collectively used usual care (UC) as a comparator against tested intervention. However, the extent and characteristics to which each study protocol defines UC does vary. Most commonly, possibly for simplicity, study protocols define UC as standard local treatment (SLT) without further elaboration. Some defined UC as SLT with additional educational support (Farmer et al., 2017; Lear et al., 2021; Loeckx et al., 2023; McDowell et al., 2015). Others included predefined and scheduled visits to monitor tested outcomes in the comparator group alongside UC (Ringbæk et al., 2015; Tupper et al., 2018). Uniquely, in addition to SLT and education McDowell et al. (2015) provided weekly exercise classes or pulmonary rehabilitation.

Studies examined a range of patient and service outcomes. Patient outcomes: quality of life (QoL) using SGRQ-C, anxiety and depression using EQ-5D and HADS, COPD assessment test (CAT), 6 min walk test, daily step count, treatment failure, number of hospital admissions, time to first hospitalisation. Service outcomes included healthcare utilisation, healthcare costs, number of exacerbations, satisfaction and cost-effectiveness.

All studies effectively randomised patients into the intervention and control arms of the study. Lear et al. (2021) enhanced the study's integrity by implementing blinding for the assessor involved in the randomization process. Though other RCTs incorporated elements of blinding within their protocol they did not directly impact the randomisation process (Ritchie et al., 2016; P. Zanaboni et al., 2023). As anticipated, patient dropout and early terminations occurred. The literature cites various reasons for these occurrences; however, all patients were consistently accounted for throughout the studies.

Methodology

The majority of studies in this literature did not employ blinding as a method to mitigate bias, however as previously mentioned 3 RCTs did utilise blinding. While Lear et al. (2021) and P. Zanaboni et al. (2023) effectively blinded the assessors of outcomes, Ritchie et al. (2016) blinded both participant recruiters and outcome assessors.

Generally, there was an even 1:1 ratio between the intervention arm and the control arm. However, both Farmer et al. (2017) and (Koff et al., 2020) allocated participants to intervention and control at a 2:1 ratio, Farmer et al. (2017) suggested that this ratio allowed them to retrieve the maximum information regarding COPD participants across the system. Distinctively, P. Zanaboni et al. (2023) developed a 1:1:1 trial to evaluate 2 different remote monitoring interventions.

Most RCTs did not have a significant difference between the study and control arms demographics. However, some RCTS identified a significant difference between the sexes (Ritchie et al., 2016; Tupper et al., 2018), likewise, Ringbæk et al. (2015) found a significant difference between smokers and non-smokers in their participant population at the end of their study.

The methodology described in these RCTs is comprehensive, offering clear insight into their randomisation protocols and the consistency of subject characteristics across study arms. Due to the type of intervention, all the selected articles were unable to blind both participants and assessors, thus allowing the possibility of performance and detection bias.

SYNTHESIS

Having appraised the final 13 RCTs, this section of the results chapter aims to synthesise and integrate the findings of the research aims, providing a comprehensive overview of the literature.

Type of DHT and level of monitoring

The first objective of this CLR was to identify various types of DHT used in COPD care. The findings from the selected RCTs have been presented using a data extraction table. Two

classes of DHT, as defined by (World Health Organization, 2023b) were identified in the selected literature, Telemedicine and personal health tracking. Telemedicine, which is defined as health care services provision from a distance, employing supplementary measuring equipment (Jakobsen et al., 2015; Koff et al., 2020; McDowell et al., 2015; Mínguez Clemente et al., 2021; Ringbæk et al., 2015; Tupper et al., 2018). Personal health tracking consists of platforms which allow individuals to track and monitor their clinical or general health (Farmer et al., 2017; Lear et al., 2021; Loeckx et al., 2023; Ritchie et al., 2016; Walker et al., 2018). Interestingly, work carried about by Zanaboni et al. (2023) had elements of both telemedicine and personal health tracking.

This CLR has identified three types of COPD monitoring systems. Firstly, the search identified 8 DHT systems and platforms that solely aim to track and monitor COPD symptoms are exacerbations (Farmer et al., 2017; Jakobsen et al., 2015; Koff et al., 2020; McDowell et al., 2015; Mínguez Clemente et al., 2021; Ringbæk et al., 2015; Tupper et al., 2018; Walker et al., 2018). Secondly, the search identified 2 DHT systems that were capable of evaluating and monitoring COPD and other conditions. COPD and chronic health failure (Ritchie et al., 2016). Uniquely, Lear et al. (2021) researched a personal health tracking DHT platform that could study Diabetes, heart failure, ischemic heart disease, chronic kidney disease, or COPD. Finally, 2 studies examined COPD-focused pulmonary rehabilitation (Loeckx et al., 2023; Zanaboni et al., 2023)

Table 4.

Table evaluating the type of DHT interventions and UC protocol used in the selected RCTs.

Author, year	Country	Health condition	DHT type	Usual care (UC)
McDowell et al., 2015	Northern Ireland	Moderate-Severe COPD	Telemedicine: Standard home-based care and home telehealth system (HomMed).	Home-based care: Delivered by the community respiratory team and GP. Additional pulmonary rehabilitation or weekly exercise class.
Jakobsen et al., 2015	Denmark	Severe – Very severe COPD	Telemedicine: Home-based telehealth system – touch screen with webcam. Additional equipment - pulse oximeter, spirometer, thermometer, oxygen compressor, and a medicine box with antibiotics, prednisone, sedatives, beta2 agonists, and anticholinergics.	Participants were hospitalised to receive standard treatment for an exacerbation.
Ringbæk et al., 2015	Denmark	Severe – Very severe COPD	Telemedicine: Home-based telehealth - tablet computer with a web camera, and a microphone. Additional equipment - spirometer, pulse oximeter, and bathroom scale.	Long-term oxygen therapy participants were cared for by outpatient or home nurses. All other participants had scheduled outpatient appointments.
Ritchie et al., 2016	USA	COPD and Chronic heart failure	Personal health tracking: Personal health tracking using Ida, an interactive voice response system application.	UC was standardised hospital protocol for discharge and post-discharge services. This included discharge planning with a nurse, some patients received additional social support or at-home health services.
Farmer et al., 2017	United Kingdom	COPD	Personal health tracking: EDGE app-based platform. The EDGE application monitors symptoms, collects data and provides personalised support.	UC participants were given all the information as those in the intervention but without access to the application.

			Additional equipment - pulse oximeter.	
Walker et al., 2018	Spain, United Kingdom, Slovenia, Estonia, and Sweden	COPD	Personal health tracking: CHROMED is an application-based platform Additional equipment - Oscillometry devices and an additional wearable device for congestive heart failure patients.	UC was not specifically detailed but was provided according to local healthcare guidelines.
Tupper et al., 2018	Demark	Severe – very severe COPD	Telemonitoring: Home-based telehealth - tablet computer with a web camera, and a microphone. Same study design as Ringbæk et al., 2015.	UC - scheduled visits at the outpatient clinics once or twice a year and unscheduled visits as required.
Koff et al., 2020	USA	Severe - very severe COPD	Telemonitoring: Home-based monitoring using Bosch Health Buddy. Additional equipment - pulse oximeter, a handheld spirometer, and a pedometer.	UC was provided by the healthcare provider as per local standards; no additional education was provided.
Mínguez Clemente et al., 2021	Spain	COPD	Telemonitoring: Used a multiparametric recording unit which was capable of recording ECG, O_2 saturation, heart rate, blood pressure, temperature, and respiratory rate.	UC was defined as home hospitalisation. This included daily home by a nurse.
Lear et al., 2021	Canada	Diabetes, heart failure, ischemic heart disease, chronic kidney	Personal health tracking: An internet program where the participant answered questions about disease-specific symptoms, biometric data and a free text field	UC received educational information about chronic disease management and internet resources for self-referencing

		disease, or COPD		
Zanaboni et al., 2023	Norway, Australia, and Denmark	Moderate, severe, or very severe COPD	Telemonitoring and personal health tracking: An integrated self-management and home-based-monitoring website Additional equipment – A treadmill, pulse oximeter, tablet computer, and a holder for the tablet computer.	UC was not specifically detailed but was provided according to local healthcare guidelines.
Loeckx et al., 2023	Belgium	COPD	Personal health tracking: Linkcare - A semi-automated smartphone application Additional equipment – Pedometer.	UC was not specifically detailed but was provided with informational leaflets alongside standard care according to local healthcare guidelines.

Patient Outcomes

Having examined the types of DHT currently utilised within COPD care research, this part focuses on evaluating the second research aim, outcomes. We begin by exploring various patient outcomes. Apart from Ritchie et al. (2016) all other RCTs identified in the explored patient outcomes.

It is important to note that the literature did not define whether a measured metric was intended to assess patient outcomes or service outcomes. Recognizing that some metrics may encompass both service and patient outcomes, a decision was made to define the wanted attributes of each outcome. Consequently, patient outcomes were defined as any measures focused on the patient's health, physiological status, experience, and satisfaction. Service outcomes were defined as measures which evaluate the performance, efficiency, and quality of healthcare services and systems. All primary and secondary outcomes were considered in the CLR, however, if a measured outcome was not statistically tested it hasn't been reported in this study.

Table 5.

Data table summarising the papers which measured patient outcomes and their results.

Author, year	Patient outcome(s)	Results
McDowell et al., 2015	- SGRQ-C (primary outcome) - EQ-5D - EQ-VAS - HADS	SGRQ-C significant improvement in the intervention group compared to the UC group EQ-5D and EQ-VAS scores declined in the intervention group and improved in the UC group, without a statistically significant difference. HADS anxiety scores recorded at six months improved in the intervention group compared to UC, with a significant difference between groups. Additionally, there was a significant non-significant, numerical improvement in the HAD depression score for the intervention arm compared with the usual care. Over the study period, there was found to be no significant difference between the intervention and UC arms.
Jakobsen et al., 2015	- Mortality (Co-primary) - Physiological measures - CCQ - SGRQ - EQ-5D	There was a statistically non-significant but numerically meaningful difference in mortality favouring the intervention group. Physiological measures: lung function, heart rate, respiratory rate, and SpO_2 did not show a statistically significant difference between intervention and UC arms. CCQ, SGRQ, and EQ-5D all improved in both arms of the trial, however, there was no statistically significant difference.
Ringbæk et al., 2015	- All-cause mortality - Exacerbations of COPD (non-hospitalisation)	The research found that there was no significant difference in mortality between treatment and UC arms. There was a statistically significant increase in COPD exacerbations (non-hospitalisation) in the treatment arm compared to the UC arm
Farmer et al., 2017	- SGRQ-C (primary outcome) - Recorded exacerbations - BMQ - MARS - EQ-5D-5L data - SCL-20 for depression - SCL-10A for anxiety	Improvements of SGRQ data of both the intervention and UC arm compared to baseline data. With a significant difference between intervention and UC. The number of exacerbations did not differ between the two study arms. However, there was a statistically significant difference in EQ-5D-5L data, in favour of the intervention group. Data regarding BMQ and MARS did not suggest a statistically significant difference between groups. The SCL-20 score decreased in the intervention group but did not show a statistically significant difference. Similarly, the SCL-10A score remained unchanged in the treatment group while it increased in the UC group, with no statistically significant difference observed.
Walker et al., 2018	-EQ-5D (coprimary) -CAT -PHQ-9 - Moderate exacerbation rate	No statistically significant differences were observed between the intervention and usual care groups in EQ-5D, CAT, PHQ-9 outcomes, or moderate exacerbation rates
Tupper et al., 2018	- 15D (primary outcome) - CAT	At follow-up, the intervention group had a statistically significant mean 15D score which was higher compared to the usual care group There was a numerical, but statistically nonsignificant, difference in CAT scores at follow-up, with the intervention group having a mean score lower than the UC group.
Koff et al., 2020	- SGRQ - Respiratory symptoms - 6-Minute Walk Test (6MWT): -COPD exacerbations	SGRQ-C overall score and individual components at 3,6 and 9 showed significant improvement in the intervention group compared to the UC group. After 9 months, the intervention group demonstrated significant reductions in smoking rates, cough, sputum production, and breathlessness. Additionally, improvements were observed in post-exercise oxygen flow and

		SpO2 levels, as well as in the 6-minute walk test, compared to the UC group. All observed differences were statistically significant.
Mínguez Clemente et al., 2021	-Time until first exacerbation, non-hospitalisation (primary outcome) - SATISFAD10 - CAT - Morisky-Green-Levine questionnaire	No statistically significant difference was found between the intervention group and UC regarding the time until the first exacerbation. Similarly, there were no significant differences between the intervention and UC group in satisfaction with homecare services (SATISFAD10), anxiety (STAI), depression, or therapeutic adherence (Morisky-Green-Levine questionnaire). However, the CAT score showed a statistically significant difference favouring the intervention group.
Lear et al., 2021	- SF-36 - heiQ - MOS-SS	SF-36 survey did not showcase a significant difference between intervention and UC. However, both heiQ and MOS-SS produced a statistically significant difference favouring the intervention group.
Zanaboni et al., 2023	- 6MWD - mMRC - CAT - EQ-5D - HADS - GSES - PGIC scale	After 6 months the intervention group benefited from a statistically significant change in CAT. A similar improvement was seen in mMRC score compared to UC but this was not maintained after 2 years. The PGIC suggests that the telerehabilitation group had a statistically significant overall change compared to the UC group. No significant difference was identified between HADS (anxiety or depression) and GSES. Despite 6MWD increasing in intervention arms statistically significant difference was not identified.
Loeckx et al., 2023	-Daily step count (Primary Care Trust Network) - Exercise tolerance -Quadriceps force -Dyspnoea - QoL -BMD	A significant improvement in the number of steps per day was observed in the intervention group compared to the UC group at visits 1, 2, and 3. However, exercise tolerance, quadriceps force, dyspnoea, QoL and bone mineral density showed no difference between UC and the intervention arm.

Abbreviation list: *St. George's Respiratory Questionnaire (SGRQ), Hospital Anxiety and Depression Scale (HADS), Clinical COPD Questionnaire score (CCQ), Beliefs about Medicines Questionnaire (BMQ), Patient Health Questionnaire-9 (PHQ-9), Medicines Adherence Report Scale (MARS), Standard Checklist 20-item Questionnaire (SCL-20), Standard Checklist 10-item Anxiety Measure (SCL-10A)*

The 12 RCTs which evaluated patient outcomes utilised various measures to explore the impact of DHT on patient outcomes. These different measures can be categorised into quality of life (QoL) measures, symptom and exacerbation measures, physiological and emotional health measures, and functional and physical measures. Due to inherent limitations, the results of all outcomes will not be expressed in this section, a comprehensive list of outcomes and results has been presented in table 5.

<u>QoL: St. George's Respiratory Questionnaire for COPD (SGRQ)</u>

Firstly, let us examine the various QoL measures utilised in the literature. St. George's Respiratory Questionnaire for COPD (SGRQ). SGRQ is a health-related quality of life (HRQoL) measure designed for patients with respiratory diseases, it aims to assess the overall impact of respiratory disease by exploring patient symptoms, activity and broader impacts (Jones, 2005). SGRQ was widely used to explore QoL in this literature (Farmer et al., 2017; Jakobsen et al., 2015; Koff et al., 2020; McDowell et al., 2015). McDowell et al. (2015) importantly identified a significant improvement of SGRQ in the intervention group compared to the UC group over the 6 months of the trial, additionally, the found that the intervention group showed significant improvements across all the individual components of the SGRQ. Koff et al. (2020) later enhanced this area of research by demonstrating a significant improvement of SGRQ in the intervention group compared to the UC group over three, six and nine months, once again finding statistically significant improvements across all individual components of SGRQ.

The data on SGRQ was not always favourable, studies weren't always able to find statistically significant improvements in SGRQ score in the intervention arm compared to UC (Farmer et al., 2017; Jakobsen et al., 2015). The robust and influential work carried out by Farmer et al. (2017) found a numerical improvement in SGRQ data of both the intervention and UC arm compared to baseline data. However, no significant difference was found between intervention and UC over the study period. Likewise, Jakobsen et al. (2015) discovered that there was a numerical in SGRQ score without a statistically significant difference.

<u>QoL: EQ-5D and EQ-VAS</u>

Similar to SGRQ, EQ-5D and EQ-VAS questionnaires are both tools used to measure HRQoL. Unlike SGRQ, EQ-5D and EQ-VAS are not tailored to chronic respiratory conditions. EQ-5D is a standardised measure consisting of five health state dimensions. EQ-VAS is part of the EQ-5D but uses a scale to ask individuals to rate their health (Xu et al., 2024).

In addition to the SGRQ patient measure, McDowell et al. (2015) measured EQ-5D and EQ-VAS. They found that at 6 months both EQ-5D and EQ-VAS scores declined in the intervention group and improved in the UC group. However, these differences were not statistically significant. Similarly, no statistically significant differences in EQ-5D were seen in the works carried out by Walker et al. (2018); Zanaboni et al. (2023). Remarkably, there was a statistically significant difference in EQ-5D-5L data, in favour of the intervention group seen in Farmer et al. (2017). This was the only RCT which produced statistically significant changes in EQ-5D favouring the DHT intervention group in the selected studies.

Though the patient outcome measures have shown a mixed level of improvement in patient QoL, anxiety and depression, and physiological symptoms, the evidence importantly does not suggest that DHT interventions are not significantly less effective than UC, increase mortality or lead to more exacerbations. Implying that the DHT that have been explored in the CLR are at the least just as effective as UC in this population of COPD patients.

Service Outcomes

The second type of outcome measured in this study is service-related outcomes, to understand if DHT can positively influence health and care services. Out of the 12 RCTs, only Loeckx et al. (2023); Tupper et al. (2018) did not report on service-related outcomes. Similar to patient outcomes, the 12 studies had a variety of measured service outcomes. The most common measure outcomes were COPD-related hospital readmissions, number of visits to various health care providers and time spent in hospital. All outcomes and their reported results have been presented in Table 6.

Research carried out McDowell et al. (2015) suggests that 6 months into the trial, there was a non-statistically significant numerical increase in the number of accidents and emergency visits, hospitalisation and longer lengths of hospital stay (hospital utilisation) in UC compared to the intervention group. Later on, Farmer et al. (2017), extracted similar results when found that the relative risk of hospital admission for the treatment arm was numerically less but not statistically significant.

Interestingly, McDowell et al. (2015) found a significantly higher number of community respiratory team and out-of-hours GP contacts in the intervention group compared to UC. Conversely, the UC care group had a statistically significant increase in GP contacts compared to the intervention arm. Similarly, Farmer et al. (2017), found the treatment arm had fewer visits to the GP or GP practice nurse, though this was not statistically significant. Moreover, Koff et al. (2020) found that the intervention arm had a statistically significant decrease in COPD-related urgent care visits compared to UC. A similar study design found that there was a statistically significant difference in the number of home visits during the trial in favour of the intervention arm. However, the study also found that the rate of hospitalisation was similar for both intervention and UC arms (Mínguez Clemente et al., 2021). Ringbæk et al. (2015) suggests that there was a statistically significant increase in visits to outpatient clinics for the UC group. However, all other service outcomes metrics showed no statistical difference between intervention and UC.

Walker et al. (2018) found that the time to first hospitalisation, general hospitalisation and patients free from hospitalisation admission were similar for both treatment and control arms. However, there was a significant difference between intervention and control with average length of hospitalisation. A study comparing slightly different COPD care Lear et al. (2021) similarly found a statistically significant difference in the number of in-hospital days between the intervention and control groups. However, a significantly lower proportion of individuals in the intervention group experienced at least one all-cause hospitalization compared to the (UC) group. Additionally, participants in the intervention group had a statistically lower risk of time to first hospitalization compared to the UC group.

Koff et al. (2020) found that the intervention group had a non-statistically significant decrease in COPD-related emergency department visits and intensive care unit hospitalisation. Later, Zanaboni et al. (2023) found similar results in their study looking at DHT for COPD-related rehabilitation, the study demonstrated that both telerehabilitation

groups experienced significantly lower incidence rates of hospitalization and emergency department presentations compared to the control group.

Jakobsen et al. (2015) did not find a statistically significant difference between intervention and UC arms for COPD-related readmission rates or length of time spent in the hospital. Similarly, the 30-day rehospitalisation levels were similar in both intervention and control groups, with no significant difference. However, the treatment arm was found to spend significantly fewer days in the hospital compared to the UC arm (Ritchie et al., 2016).

The data presents a mixed picture of service outcomes, some of the RCTs were able to identify statistically significant differences between research arms in favouring DHT, whilst others showed no significant difference. Importantly, some study metrics favour UC over intervention.

Table 6.

Data table summarising the papers which measured service outcomes.

Author, year	Service outcomes
McDowell et al., 2015	- Hospital utilisation and exacerbations - Community respiratory team contact - Out-of-hours GP contact - GP contract
Jakobsen et al., 2015	-COPD-related readmission (coprimary) - Secondary - Length of hospitalization
Ringbæk et al., 2015	Number of hospital admissions in 6 months (Primary Care Trust Network) - Number of visits to emergency rooms - Number of visits to the outpatient clinic - Length of hospital admissions (days) - All-cause hospital visits, admissions - Time to first hospital admission - Time to first hospital admission caused by exacerbation in COPD
Ritchie et al., 2016	- 30-day rehospitalisation (any cause) (Primary Care Trust Network) - Number of patient days spent in the hospital versus at home over 30 days (Community tenure)
Farmer et al., 2017	- Number of admissions and days in hospital
Walker et al., 2018	- Time to first hospitalisation (co-primary) - General hospitalization - Patients free from hospitalisation admission - Average length of hospital stay
Koff et al., 2020	-COPD and non-COPD-related healthcare utilization
Mínguez Clemente et al., 2021	- Mean time of home hospitalisation - Home visits
Lear et al., 2021	- In hospital days - All-cause hospital days - Time to first hospitalisation
Zanaboni et al., 2023	- Combined number of hospitalizations and ED presentations (Primary Care Trust Network) - Hospitalizations and emergency department presentations (analysed separately)

Cost-Effectiveness

The final objective of this study was to explore cost-effectiveness data. Out of the selected studies, only 4 reported cost-effectiveness (Koff et al., 2020; McDowell et al., 2015; Mínguez Clemente et al., 2021; Walker et al., 2018).

Due to the study protocol, metrics, and currency used it was not possible to directly compare the results of each study, therefore this section aims to present an outline of cost-effectiveness data.

McDowell et al. (2015) over the 6 months, calculated that the incremental cost-effectiveness ratio (ICER) was £203,900, hence it was concluded that the DHT in the present study was not cost-effective. Similarly, Walker et al. (2018) did not find a statistically significant change in quality-adjusted life years (QALYs) between intervention and control groups. However, there was a statistically significant reduction in cost per patient in the intervention group compared to UC. The economic analysis indicated a reduction in healthcare costs within the intervention group, with an average annual savings of €1,712 per patient. These savings were attributed to reduced hospital expenses.

Conversely, both Koff et al. (2020); Mínguez Clemente et al. (2021) found that the DHT saved costs. Koff et al. (2020) estimated a cost saving of $4,359 per patient per year with the intervention group. It was identified that the majority of cost savings were seen from a reduction in ICU hospitalisations. Likewise, Mínguez Clemente et al. (2021) suggest that the difference in cost in favour of the control group was € 1.40, suggesting that it costs per patient may be identical between intervention and control arms.

This contradicting data showcases the novelty of DHT, it is possible to assume that based on location, variants of DHT used with different cost-effectiveness conclusions may be reached.

DISCUSSION

Having carried out a narrative approach CLR, this study has identified 12 RCTs which transparently and robustly explore patient and service outcomes concerning the use of DHT within COPD care. This CLR began by thoroughly evaluating the fields of NCD, COPD and DHT. It was posed that the evolving field of DH has the potential to assist patients and healthcare services to compensate for deficits seen in today's healthcare service by leveraging DHT to promote self and remote healthcare monitoring of NCDs, such as COPD. COPD has been identified as an influential disease which increases healthcare use, owing to the high risk of exacerbations, multiple lifestyle factors impact patient health and increase the risk of comorbidities such as cardiovascular disease, osteoporosis and cancer (Rabe & Watz, 2017).

A literature search was carried out on PubMed, SCOPUS and Cochrane CENTRAL which yielded a search result of 302 articles. Using predefined inclusion and exclusion criteria the 302 articles were narrowed down to 22 RCTs. During this process, as previously mentioned, the database selection, the lack of grey literature and the unchecked literature exclusion process increased the risk of bias and inaccuracy in this study. To maintain robustness a partially systematic approach was used in the methodology of this CLR (Atkinson & Cipriani, 2018; Bramer et al., 2017).

This CLR aimed to evaluate DHT designed for COPD care, assessing their impact on patient outcomes, service outcomes and cost-effectiveness. In essence, the CLR want to understand if DHT can improve healthcare services for COPD patients. The results yielded from the 12 RCTs studied in this CLR suggest that though there is potential for improvement, the evidence is currently mixed and seemingly unrepeatable with some positive measures promoting the use of DHT and other measures which suggest that DHT is not more effective than UC. Similar conclusions have been reached by various other study groups.

During this critical review, it was identified that there is a growing number of digital health monitoring devices currently available. The varied scope of these technologies could facilitate service provider choice; however, the currently limited research may inhibit informed decision-making. Likewise, though not statistically significant, the RCTs have shown that digital

health monitoring has the potential to have positive impacts on patient-related outcomes. The critical review identified a need for further comparative clinical effectiveness studies to aid service providers' decision-making and further research on patient outcomes to ensure significant clinical effectiveness. Even though the research is limited, the RCTs analysed in this review showcase a huge potential for digital health monitoring to improve asthma and COPD patient outcomes and potentially improve service provisions and service outcomes in the future.

CONCLUSION

DHT can positively influence COPD healthcare services, and it may be an important tool for future COPD services. However, presently there is a need for further organisational restructuring of services and investment into information infrastructure to allow DHT to impose the maximum impact it may have.

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APPENDIX

Appendix 1.

Database searched	Date of Search	Search String	Filters / Limiters applied[2]	# of Records	After duplicates removed	# of Records excluded after title/abstract
BIBLIOGRAPHIC DATABASES:						
PubMED	07/08/2024	(((“search”[All Fields] OR “searched”[All Fields] OR “searches”[All Fields] OR “searching”[All Fields] OR “searchs”[All Fields]) AND ((“search”[All Fields] OR “searched”[All Fields] OR “searches”[All Fields] OR “searching”[All Fields] OR “searchs”[All Fields])) AND (“digital health”[MeSH Terms] OR “Telemedicine”[MeSH Terms:noexp] OR “Distance Counseling”[MeSH Terms] OR “Remote Consultation”[MeSH Terms:noexp] OR “digital health”[All Fields] OR “Virtual health”[Title/Abstract:~1] OR “Digital therapies”[Title/Abstract:~1] OR “Digital interventions”[Title/Abstract:~1] OR “mobile health technology”[Title/Abstract:~1] OR (“telehealth s”[All Fields] OR “Telemedicine”[MeSH Terms] OR “Telemedicine”[All Fields] OR “telehealth”[All Fields]) OR (“Telemedicine”[MeSH Terms] OR “Telemedicine”[All Fields] OR “telemedicine s”[All Fields]) OR (“Telemedicine”[MeSH Terms] OR “Telemedicine”[All Fields] OR “ehealth”[All Fields]))) OR (“mhealth s”[All Fields] OR “Telemedicine”[MeSH Terms] OR “Telemedicine”[All Fields] OR “mhealth”[All Fields])) AND (“pulmonary disease, chronic obstructive”[MeSH Terms:noexp] OR “Asthma-Chronic Obstructive Pulmonary Disease Overlap Syndrome”[MeSH Terms] OR “bronchitis, chronic”[MeSH Terms] OR “Pulmonary Emphysema”[MeSH Terms] OR (“pulmonary disease, chronic obstructive”[MeSH Terms] OR (“pulmonary”[All Fields] AND “disease”[All Fields]) AND “chronic”[All Fields] AND “obstructive”[All Fields])) OR “Chronic obstructive pulmonary disease”[All Fields] OR “copd”[All Fields]) OR “Chronic obstructive pulmonary disease”[All Fields] OR “Chronic Bronchitis”[All Fields] OR (“emphysema”[MeSH Terms] OR “emphysema”[All Fields] OR “emphysemas”[All Fields] OR “Pulmonary Emphysema”[MeSH Terms] OR (“pulmonary”[All Fields] AND “emphysema”[All Fields]) OR “Pulmonary Emphysema”[All Fields])) AND (“Self-Management”[MeSH Terms] OR “monitoring, ambulatory”[MeSH Terms:noexp] OR “monitoring, physiologic”[MeSH Terms:noexp] OR “Self Care”[MeSH Terms:noexp] OR (“ego”[MeSH Terms] OR “ego”[All Fields] OR “self”[All Fields]) AND “monitor*”[All Fields]) OR “Self-Management”[All Fields] OR ((“remote”[All Fields] OR “remotely”[All Fields] OR “remoteness”[All Fields] OR “remotes”[All Fields]) AND “monitor*”[All Fields]) OR ((“outpatient s”[All Fields] OR “outpatients”[MeSH Terms] OR “outpatients”[All Fields] OR “outpatient”[All Fields]) AND “monitor*”[All Fields]) OR ((“home environment”[MeSH Terms] OR (“home”[All Fields] AND “environment”[All Fields]) OR “home environment”[All Fields] OR “home”[All Fields]) AND “monitor*”[All Fields]))	Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Portugal, Spain, Sweden, UK and the USA 2014-2024	107	96	22
SCOPUS	07/08/2024	TITLE-ABS-KEY(“digital health” OR virtual W/1 health OR digital W/1 therapies OR digital W/1 interventions OR “mobile health technology” OR telehealth OR telehealth OR ehealth OR mhealth) OR INDEXTERMS (“Digital Health” OR “Telemedicine” OR “Distance Counseling” OR “Remote Consultation”) AND TITLE-ABS-KEY (copd OR “Chronic obstructive pulmonary disease” OR “Chronic Bronchitis” OR emphysema) OR INDEXTERMS (“Pulmonary Disease, Chronic Obstructive” OR “Asthma Chronic Obstructive Pulmonary Disease Overlap Syndrome” OR “Bronchitis, Chronic” OR “Pulmonary Emphysema”) AND TITLE-ABS-KEY (“Self monitor* ” OR “self management” OR “Remote monitor* ” OR outpatient AND monitor* OR “Home monitor* ”) OR INDEXTERMS (“Self Management” OR “Monitoring, Ambulatory” OR “Monitoring, Physiologic” OR “Self Care”)	2014-2024			
Cochrane CENTRAL	07/08/2024	#1(“Digital health”) (Word variations have been searched)1400 #2Virtual near/1 health211 #3Digital near/1 therapies22 #4Digital near/1 interventions414 #5“mobile health technology”190 #6Telehealth4567 #7Telemedicine7120 #8eHealth2339 #9Mhealth3204 #10(OR #1-#9)16047 #11MeSH descriptor: [Telemedicine] this term only4123 #12MeSH descriptor: [Digital Health] explode all trees15 #13MeSH descriptor: [Distance Counseling] explode all trees28 #14MeSH descriptor: [Remote Consultation] this term only455 #15(OR #11-#14)4552 #16(OR #10-#14)16349 #17COPD20358 #18“Chronic obstructive pulmonary disease”15048 #19“Chronic Bronchitis”1968 #20Emphysema2042 #21(OR #17-#20)26352 #22MeSH descriptor: [Pulmonary Disease, Chronic Obstructive] this term only7861 #23MeSH descriptor: [Asthma-Chronic Obstructive Pulmonary Disease Overlap Syndrome] explode all trees3 #24MeSH descriptor: [Bronchitis, Chronic] explode all trees212 #25MeSH descriptor: [Pulmonary Emphysema] explode all trees407 #26(OR #22-#25)8311 #27(OR #21-#25)26816 #28Self monitor*21099 #29“self management”12069 #30Remote monitor*3177 #31Outpatient monitor*6037 #32Home monitor*11473 #33(OR #28-#32)41832 #34MeSH descriptor: [Self-Management] explode all trees1278 #35MeSH descriptor: [Monitoring, Ambulatory] this term only691 #36MeSH descriptor: [Monitoring, Physiologic] this term only2816 #37MeSH descriptor: [Self Care] this term only6294 #38(OR #34-#37)9855 #39(OR #33-#37)47358	2014-2024 English	143	108	38
Totals				302	239	78

Appendix 2

Article:	Year	Section A: Is the basic study			Section B: Was the study			Section C: What are the results?			Section D: Will the results		Results
Y:3,SW:2,N:1,CT:0		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	
Follow-up with Telemedicine in Early Discharge for COPD Exacerbations: Randomized Clinical	2021	3	3	3	0	3	3	3	3	3	3	3	30
Telemonitoring in Chronic Obstructive Pulmonary Disease (CHROMED). A Randomized Clinical Trial	2018	3	3	3	1	3	2	3	3	3	3	2	29
Long-term Telerehabilitation or Unsupervised Training at Home for Patients with Chronic Obstructive Pulmonary Disease A Randomized Controlled Trial	2023	3	3	3	2	3	3	3	3	2	2	2	29
The E-Coach technology-assisted care transition system: a pragmatic randomized trial	2016	3	3	3	2	3	3	3	3	2	2	2	29
Self-Management Support Using a Digital Health System Compared With Usual Care for Chronic Obstructive Pulmonary Disease: randomized Controlled Trial	2017	3	3	3	1	2	3	3	3	2	3	3	29
Impact of proactive integrated care on chronic obstructive pulmonary disease	2020	3	2	3	0	3	2	3	3	3	3	3	28
Assessment of an Interactive Digital Health-Based Self-management Program to Reduce Hospitalizations Among Patients With Multiple Chronic Diseases: a Randomized Clinical Trial	2021	3	3	3	2	3	2	3	3	2	2	2	28
A randomised clinical trial of the effectiveness of home-based health care with telemonitoring	2015	3	3	3	1	3	2	3	1	3	3	2	27
Sustaining training effects through physical activity coaching (STEP): a randomized controlled trial	2023	3	3	3	1	3	3	3	3	2	2	1	27
Home-based telehealth hospitalization for exacerbation of chronic obstructive pulmonary disease: findings from "the virtual hospital" trial.	2015	3	3	3	1	3	3	3	3	1	2	2	27
Effect of tele health care on exacerbations and hospital admissions in patients with chronic obstructive pulmonary disease: a	2015	3	3	3	0	3	3	3	2	2	3	2	27
Effect of tele–health care on quality of life in patients with severe COPD: A randomized clinical trial	2018	3	3	3	0	3	3	2	3	2	3	2	27
Home telemonitoring for patients with acute exacerbation of chronic obstructive pulmonary disease: A randomized controlled trial	2016	3	3	3	1	2	3	3	3	2	2	1	26
Person-centred telephone-support is effective in patients with chronic obstructive pulmonary disease and/or chronic heart failure-six-month follow-up of a randomized controlled trial	2018	3	2	3	1	0	3	3	3	3	2	3	26
Technology-Enabled Self-Management of Chronic Obstructive Pulmonary Disease With or Without Asynchronous Remote Monitoring: randomized Controlled Trial	2020	3	3	3	0	3	3	3	1	2	3	1	25
A smart mHealth tool versus a paper action plan to support self-management of COPD exacerbations: a randomised controlled trial	2019	3	3	3	0	3	2	3	3	1	2	2	25
Efficacy of an mHealth intervention to stimulate physical activity in COPD patients after pulmonary rehabilitation	2016	3	3	3	2	3	3	3	2	1	1	1	25
A multicentre, randomized controlled trial of telehealth for the management of COPD.	2018	3	3	3	1	3	0	3	3	1	3	1	24
It's LiFe! Mobile and web-based monitoring and feedback tool embedded in primary care increases physical activity: A cluster randomized controlled trial	2015	3	2	3	1	3	3	3	3	0	3	0	24
Telecare for diabetes, CHF or COPD: effect on quality of life, hospital use and costs. A randomised	2015	3	2	3	1	3	3	3	1	2	1	1	23

Appendix 18: The Effectiveness of Patient-facing Applications in the Management of Individuals with Asthma and Healthcare: A literature Review

Swansea University

Department of Public Health and Social Care

The Effectiveness of Patient-facing Applications in the Management of Individuals with Asthma and Healthcare: A literature Review

Written by Ojulu Obang

Research Project Supervisors: Professor Gareth Davies and Dr Sue Carnes Chichlowska

Abbreviations

AAP……Asthma Adherence Pathway

ACT …….. Asthma Control Test

ACQ……Asthma Control Questionnaire

Apps …….. Applications

COPD……..……Chronic Obstructive Pulmonary disease

ER …….. Emergency Room

FEV1……Forced Expiratory Volume in one second

GINA ……Global Initiative for Asthma

HITAM……Health Technology acceptance Model

ICST…….. Institute of Clinical Science and Technology

ITU……International Telecommunication Unit

KASE-Q…… Knowledge, Attitude and Self-efficacy Asthma Questionnaire

NICE……National Institute for Care and Excellence

MARS…….. Mobile Application Rating Scale

MAQLQ……Mini-asthma Quality of Life

QALY ……Quality Adjusted Life Years

QoL…….. Quality of Life

PEF…….. Peak Expiratory Flow

PEFR……Forced Expiratory Flow Rate

RCT ……Randomized Controlled trail

SMS ……Short Message Service

TAM ……Technology Acceptance Model

WHO…….. World Health Organization

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Problem Statement

Apps provide promising prospects for chronic diseases including asthma self-management. Several studies have reported the relevance of the apps in managing individuals with bronchial asthma by adapting real-time symptom management, reminders, and care plans. However, how effective these apps are, remains unsettled and raises concerns about their application for asthma management and healthcare.

Research questions

Despite smartphone apps being touted as revolutionizing healthcare due to their seamless interaction between patients and healthcare providers and ease of access to healthcare, data about their effectiveness remain inconclusive and researchers have called for robust research to determine the effectiveness and cost-effectiveness for use in asthma self-management (Farzandipour et al., 2024; Krebs & Duncan, 2015; Quach et al., 2023; Van De Hei et al., 2022). Therefore, in this research the following questions are asked for review. They are:

1. Are apps clinically effectiveness for asthmatic patients and in healthcare?
2. Are apps cost-effective in asthmatic patients and healthcare?
3. What are the enabling factors and gaps for these apps' usage
4. How to integrate apps used in asthma into healthcare?

Significance of study

For decades the topic of apps in healthcare and asthma management has been recognized, and apps have made their way into clinical practice, mostly uninvestigated and brought into practice mainly by technological advancement and market demands. However, data on the effectiveness of apps in the management of patients with

asthma remains inconsistent. Particularly, only very few economic evaluation studies have been conducted to assess the cost-effectiveness of apps in asthma. This research will fill the gaps by investigating both clinical outcomes and the cost-effectiveness of these apps in managing people with asthma. In addition, this paper will review the available strategies best for integration of these apps into healthcare.

Research aims and Objectives

This review aims to explore the effectiveness in management of individuals with bronchial asthma and healthcare. It critically examines how the use of apps affects outcomes in terms of clinical, economic, environmental effects on patients and healthcare, and ultimately how well can we integrate these innovations into existing workflows.

To answer the above aim and research questions the following objectives are formulated and specifically, the research objectives are:

1) Evaluate the clinical effectiveness of apps in asthmatic patients and healthcare
2) Evaluate the cost-effectiveness of apps in asthmatic patients and healthcare
3) Assess the enablers and barriers in implementing mobile applications
4) Assess ways to integrate apps into healthcare

Research Scope

This review examines the effectiveness of apps in the management of patients with bronchial asthma and healthcare from 2010 to current. By doing so, it reviews relevant scholarly articles with the focus of assessing currently available apps for asthma self-management, potential benefits, and effectiveness in clinical practice. The work also will dive further into unpacking gaps and procedures that influence the usage of apps

in healthcare. In the end, the research will try to recommend solutions of integrating apps into the healthcare.

Introduction

Asthma affects around 360 million people, the most common chronic disease in children, significantly contributing to the global economic burden, lowering quality of life, and each year causing 250,000 deaths worldwide (Ghozali et al., 2023; Global Asthma Report, 2022; Levy, 2015; Salim et al., 2023).The United Kingdom is no exception; each year 160,000 cases of asthma are diagnosed, 8 million people from all ages have the disease, and about 5.4 million individuals are receiving treatment (NICE, 2023).

Asthma is a multifactorial, chronic inflammatory disease of the airways, characterized by respiratory symptoms and expiratory air flow limitation (GINA, 2018). Effective asthma management involves taking medications, monitoring symptoms, following a personal action plan, identifying and reducing environmental triggers, visiting doctors, and communicating with providers about treatment (Kocsis et al., 2019). Essentially, the management of asthma revolves around asthma self-management, partnership ,environmental factors, and medications (Wu et al., 2015).

The World Health Organization (WHO) and the International Telecommunication Unit (ITU) launched the ‘Be Healthy, Be Mobile’ campaign in response to the rapidly expanding influence of mobile technologies in healthcare (WHO, 2022, p. 1). The mobile health apps or applications (*hereafter ,apps*) encompasses the use of mobile computers devices (e.g. mobile phones, tablets, and

other wireless devices, medical sensors and communication technologies) to improve management of chronic diseases (Whitehead & Seaton, 2016; Wu et al., 2015). In the UK, digital innovative approaches such as National Health Services (NHS) apps have been developed for patients to access NHS services and are likely to be integrated into primary care services (Asthma UK, 2023).

By the year 2019, 2.5 billion people had smartphones worldwide (Taylor & Silver, 2019), more than 500 million people worldwide were expected to use healthcare apps, and more than 98% of adult UK citizens currently own smart phones (Baker, 2024; Y. Wang et al., 2021). There are over 325,000 apps owned for smart phone users; about 200 apps are introduced every single day, and more than 500 apps are in use for asthma self-monitoring worldwide, but there is a dearth of scientific data backing most of these apps, and their quality varies significantly (Kagen & Garland, 2019; Kouri & Gupta, 2023; Tinschert et al., 2017).

NHS Wales introduced two free-to-use self-management apps in 2020 called the Asthmahub and Asthmahub for parents, to assist users in managing their asthma care and treatment (Asthma+UK, 2023). According to the report by Institute of Clinical Science and Technology, significant results have been achieved in Wales with digital health technology to modify population-level behavior, such as enhanced patient well-being, altered prescription practices and decreased service requirement (ICST, 2022a). Along with COPDhub, currently more than 20,000 of these apps are downloaded and used by 99% general practitioners (GP) practices across Wales(NHS Wales, 2022). However, there is no research conducted on these apps and the report called for in-depth understanding of the app usage over a longer period, its quality, barriers and how to integrate apps into NHS Wales.

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According to Ramsey (2019), apps have the capacity to enhance asthma self-management by incorporating medication prompts, enabling self-monitoring of symptoms, enhancing the accessibility and quality of information exchanged with healthcare providers, and offering educational resources to patients and parents. Apps can help patients manage their asthma, enhance their quality of life ,encourage drug compliance ,and lower the total cost of asthma care (Khusial et al., 2020; Poowuttikul & Seth, 2020).

Nevertheless, there is a lack of conclusive data to determine the effectiveness and efficacy of these applications in the self-management of asthma (Himes et al., 2019). Other researchers have stated concerns and labelled apps ineffective for the self-management of asthma due to conflicting findings (Gaynor et al., 2020; Marcano Belisario et al., 2013). Also the available evidence supporting the efficacy of even the best apps is limited, and the majority of apps fail to provide significant benefits, especially for chronically ill patients (Gordon et al., 2020; Singh et al., 2016). In extension, apps often lack comprehensive or universal clinical evaluation or clinical trials and do not adhere to clinical guidelines; they are not controlled by government agencies in most cases (Kvedarienė et al., 2022; Tinschert et al., 2017). It is therefore imperative to subject these novel technologies to rigorous testing to ensure compliance with privacy regulations, assess their acceptance, evaluate their efficacy, and cost-effectiveness (Bousquet et al., 2019).

Background and Effects of Apps on Behavior

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The support for applications and self-management is full of promise. Findings from systematic reviews for intervention of chronic diseases management have shown promising aspect particularly in improving self-management and health outcomes (Lee et al., 2023; Tinschert et al., 2017). Positive strategies such as use of automated text reminders, regular and precise monitoring of symptoms (sometimes in real time) and shared decision making are associated with patients increased knowledge and better self-management (Lee et al., 2023).

An important insight was given by Anderson (2016) combining three models, the Health Technology Acceptance Model (HITAM), the Technology Acceptance Model (TAM), and Mobile Application Rating Scale (MARS) to examine consumers' experience based on engagement, functionality, information management and ease of use. The finding indicates that chronic disease management using mobile health applications greatly improves treatment. In addition, the review by Tinschert and colleagues (2017) indicated that apps could actually change behavior crucial for asthma self-management. Evidence from robust research with 270 randomized controlled trials (RCTs) demonstrated that asthma self-management can improve asthma control, minimize unplanned visits, and reduce overall healthcare costs (Jácome et al., 2020). Moreover according to the self-regulation theory, individuals can control their own behavior by self-monitoring, goal setting, feedback, self-reward, self-instruction all of which are possible using mobile phone applications (Sage et al., 2017).

Smartphone Applications for Asthma management

Patient-facing applications for asthma foster the development of streamlined platforms and useful tools for the management of relevant healthcare data among a

range of healthcare by using wireless devices, mobile medical devices, and/or telemedicine (Kagen & Garland, 2019; Whitehead & Seaton, 2016). Apps can integrate the features of SMS and web-based mhealth solutions (Alquran et al., 2018).

The swift development of mobile technology has created new prospects for the digital revolution of healthcare and the ongoing expansion of the availability of mobile cellular networks (Bousquet et al., 2019). This development of mobile health, especially for the past ten years, is unparalleled and was primarily influenced by global market demands as well as the rapid advancement of smart phone applications and widespread use of digital technologies (Istepanian, 2022). However ,despite the many positive findings to support asthma self-management, the effectiveness of these apps is not yet thoroughly evaluated (Ghozali et al., 2023).

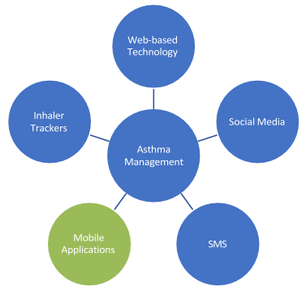
In Wales, through the Institute of Clinical Science and Technology, the development of the health hub apps such as Asthmahub, Asthmahub for parent and COPDhub has changed the service delivery and patient management practice in Wales (NHS Wales, 2022). The NHS Wales (2022) conducted survey on Asthmahub on the asthma self-management. This survey shows significant improvement in clinical outcomes, the health system, and massive savings due to the advent of these apps. As a result, about 90% of patients are confident the apps helped them manage their condition, more than half reported that they are not reliant on their rescue medications, and 50% of them believed their monthly score improved. However, as far as our knowledge is concerned there is no available research conducted on the effectiveness of these apps.

The classification of apps in use for asthma is enormous and still growing; they are divided into four distinct classes based on the innovation type, which include:

standalone apps, digital inhalers, digital spirometers, and other mHealth devices used in asthma care depicted in Figure 1 below (Kouri & Gupta, 2023). The authors reported that currently over 500 apps related to asthma are available for health education, symptom recording, tracking inhaler use, displaying environmental alerts, and reminding users to take their medications. The standalone asthma apps enable users to input, save or gather personal or third party data without the capability to transmit this information to others, but other require connection to other devices such as inhaler (Gordon et al., 2020; Kagen & Garland, 2019)

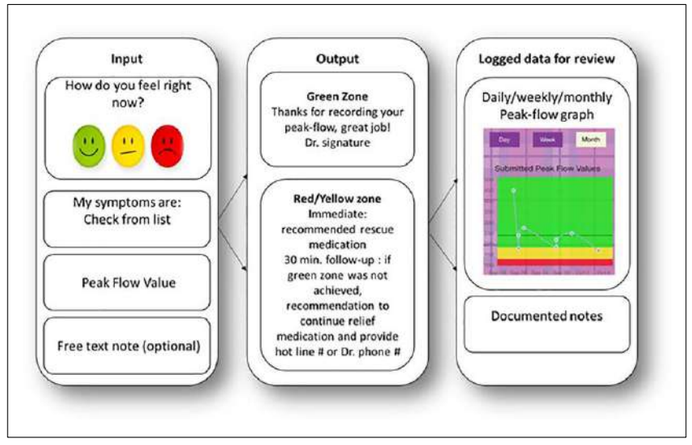
Available features in most asthma applications are asthma educational, peak flow monitoring, and care plans (Camacho-Rivera et al., 2020; Wu, 2016). See below Figure 2. Other recommended features in apps include medical appointment tracking, notification features, health snapshots, and a clinical asthma questionnaire (Cook et al., 2016; Farzandipour et al., 2017; Tinschert et al., 2017). According to the Institute of Clinical Science and Technology, the functions included in the three developed above-mentioned apps are personalized care plans, peak flow monitoring and recording, advice and support ,and educational videos(NHS Wales, 2022).

Figure 1: Technology-based tools available for managing asthma.



Source: Clinical Reviews in Allergy & Immunology (2020) 59:19–37: P. Poowuttikul and D. Seth: *New Concepts and Technological Resources in Patient Education and Asthma Self-Management*.

Figure 2: Apps features and functions



Source: Health Informatics Journal 2020, Vol. 26(1) 342–353: Tali, Schneider L,Baum ,A.Alman, M.Couluris*:* Users' perceptions of asthma self-management mobile app tailored for adolescents.

Clinical outcomes of Apps

Research on the impact of mobile apps for managing asthma is inconsistent; however, new data show the benefits of using these apps in terms of adherence to medication, self-management, asthma control, reduced exacerbation, and quality of life (Genberg et al., 2023; Khusial et al., 2020; Kocsis et al., 2019). For example, previous studies, such as one multicenter randomized controlled trial conducted by Ryan and colleagues (2012) using the Asthma Control Questionnaire (ACQ) and KASE-Q (i.e., knowledge, attitude and self-efficacy asthma questionnaire), concluded that mobile health applications are neither clinically effective nor cost-effective compared to paper-based monitoring. A Cochrane systematic review by Marcano Belisario and colleagues (2013) using three trials questioned the effectiveness of mobile applications for self-management, calling for further research with sufficient evidence.

On the other hand, some studies showed the effectiveness of these new innovations. For example a recent study on effects of apps on self-management demonstrated that apps are effective in improving asthma control showing an improved ACT scores among young asthmatic patients (Ghozali et al., 2023). This findings are supported by previous studies that indicated that apps may clinically be advantageous in improving asthma symptoms and self-management, and likely to improve clinical practice (Sunjaya et al., 2022; Tinschert et al., 2017). A pilot study that evaluated Asthma Adherence Pathway (AAP) that uses patient and clinician strategies to enhance adherence has shown how these applications can change the way care is given, leading to asthma adherence and control of the disease (Weinstein et al., 2019).

Munteanu et al. (2020), has observed significant asthma control and self-management improvement compared to the control groups. The author showed that

the presence of videos to remind people about appropriate inhalation procedures, lung rehabilitations exercise, and care plans is crucial for the achievement. Similar findings were documented in other meta-analyses showing that patients that used apps are less likely to use healthcare while maintaining quality of life and resultant asthma control (Hodkinson et al., 2020; Hui et al., 2017). A qualitative study among adolescents using mobile apps to manage their asthma confirmed that use apps can enhance accessibility to asthma education and aid adolescents to manage their condition better (Schneider et al., 2020).

Lung Function Test

A proof-of-concept study that employed the Asthma Control Test (ACT) survey provided confirmation for the effectiveness of apps in self-management to improve pulmonary function (Cook et al., 2016). This study shows significant improvement among patients with uncontrollable asthma while using apps, manifested by the improvement of the overall ACT score, increase in forced expiratory volume in one second (FEV1) spirometry score, and decreased number of patients requiring course of systemic corticosteroids after 6 months.

In addition ,a randomized controlled trial on 89 patients by Liu and colleagues (2011) has shown that applications result in an improved pulmonary function test. The study compared the traditional and interactive mobile based self-care system to monitor asthma the daily symptoms (i.e., sleep quality, cough severity, difficulty in breathing and effect on physical activities), and daily peak expiratory flow rate. The findings showed significant improvement in the peak expiratory flow rate (PEFR) at 4 (378.2 ± 9.2 L.min^{-1}; $p=0.020$) and 6 (382.7 ± 8.6 L.min^{-1} $p=0.01$) months, better quality of life as determined by short form-12 (SF-12), physical component score and reduced

exacerbation and decrease in unscheduled visits compared to the control group. Principally, the apps enable patients to monitor their own peak expiratory flow (PEF) ,which is likely to revolutionize the management of asthma (Antalffy et al., 2020).

Exacerbation of Asthma

A study published recently demonstrated that there is a significant reduction in the number of asthma-related medical visits and attacks between patients who used apps and those who do not (Genberg et al., 2023). According to these findings patients who used the patient-facing applications visited healthcare infrequently after using the apps (relative decline 0.84, 95% CI 0.74 to 0.96), and comparatively, the healthcare visits remained the same for patients that did not activate their apps (relative decline 0.96, 95% CI 0.76 to 1.2). However, the difference between the two groups was not statistically significant. This finding was in line with other studies, which indicated that apps may enhance asthma monitoring by reducing unplanned visits, exacerbation and improved pulmonary function (FEV1 and PEFR) and improving and quality of life (Kim et al., 2016; Liu et al., 2011). Practically, the ICST developed Asthmahub apps in Wales are yielding results ,with patients who were willing to interact with the mobile app reporting 36% fewer visits to GPs and a 19% reduction in emergency department admission (ICST, 2022b). Furthermore, the survey revealed that more than 90% of patients found the applications beneficial for their disease management.

In contrast , recent randomized controlled trial conducted in France among children and adults found no decrease in the unscheduled medical visits for combined digital action plan (DAP) and written action plan (WAP) users compared to the paper action plan alone (Beydon et al., 2023). Nonetheless, the study shows that digital action plans using apps were used less frequently compared to paper based action

plans. The reduced utilization can be attributed to the unavailability of WAP, smartphone or network problems occurring in 13 (8.6%) and 12(7.9%) of the 151 exacerbations respectively. In the same vein, previous studies on children showed no demonstrable effect to decrease asthma related ER visits or hospitalizations (Stukus et al., 2018; To et al., 2020).

Patient Reported Outcomes and Measures

Medication Adherence

Many studies have documented increased adherence using mobile applications through reminders and education materials (Kaye et al., 2021; Morrison et al., 2014; Mosnaim et al., 2021; Poowuttikul & Seth, 2020). For example, a study on regular use of apps and self-management found increased patients' knowledge and confidence, which are crucial for medication adherence and asthma control (Huang & Matricardi, 2019). This is in line with retrospective analysis from the United States examining the effect of application usage for asthma and COPD, has indicated that objective apps utilization by patients is associated with higher compliance and proper medication intake (Kaye et al., 2021). The study found a positive correlation between medication adherence and the frequency of opening the app daily, and the duration of the time spent within the app.

Other studies have indicated improved clinical outcomes and adherence in patients using apps compared with paper based standard care (Miller et al., 2017). A systematic review conducted on Google Play and the App Store for patients using mobile applications for asthma management with an inhalers embedded sensor found a positive association between apps and reduced rescue inhaler use, inhaler

adherence, and patient satisfaction (Nguyen et al., 2020). This study found a notable correlation between the amount of time spent in the app and daily app openings and medication compliance.

However, there is a scarcity of research on quantifiable measures of smart phone applications and its correlation with intended outcomes (Kaye et al., 2021; Morrison et al., 2014). In addition, Tran and colleagues (2014) systematic review from 5 RCTs and one pragmatic study findings though medication adherence was increased in this study , there was no improvement in clinical outcomes. This finding is supported by observational studies that found discrepancy between patient perception about adherence and the clinical outcomes (Carvalhal et al., 2021; Jácome et al., 2021). Adherence discrepancies may stem from patients' lack of knowledge, discordance in reporting between patients and doctors(Jácome et al., 2019), and app overestimation, necessitating objective monitoring.

Quality of Life

Multi-functional apps possess potential to improve quality of life ,self-management ,alleviate symptoms and promote well-being for asthma patients (Kiani et al., 2022; Quach et al., 2023). A longitudinal study conducted in United states demonstrated that apps were associated with increased patients knowledge and improved quality for patients who utilized apps, causing decreased hospitalization and use of prednisolone after six months follow-up visits(Hsia et al., 2020).

One randomized controlled trial found that apps are associated with positive quality of life for the participants using Mini-Asthma Quality of Life (MAQLQ) measured in terms of quality of life, self-efficacy, and self-reported control of asthma as compared to the control group after six months of exposure (Ahmed et al., 2016). However, there was no significant improvement in the overall asthma control. This is in keeping with a recent randomized controlled trial that demonstrated that mobile applications are associated with asthma control and improved quality of life compared to traditional care (Farzandipour et al., 2024).

While paper-based questionnaires are perceived as burdensome and a source of errors, mobile applications provide a better alternative. A study by Kamstra et al.(2022) has demonstrated that mobile applications are useful tools to measure quality of life using EQ-5D-5L which is likely to reduce the response burden. This is supported by other studies conducted using children version EQ-5D-Y and adults using EQ-5D-5L respectively that showed that health related quality of life of asthmatic patients can be monitored using apps efficiently (Hernandez et al., 2019; Mayoral et al., 2022).

Patient Satisfaction

High levels of patient satisfaction have been reported among users of these applications, and patients appreciated the support provided by the apps (Morita et al., 2019). A controlled trial by Khusial and colleagues (2020) found higher satisfaction among participants that used myAirCoach apps compared to the control group. Another study from a real-world environment observed similar findings indicating satisfaction and an increase in the adoption of the new digital technology in healthcare(Wedel et al., 2024). More specifically , patient satisfaction and retention

may be due to increased accessibility of specialists to give care remotely (Poowuttikul & Seth, 2020).

Cost-Effectiveness of Apps

While studies on economic evaluation remain scarce, mobile applications enable convenient access to healthcare providers and reduce waiting times (Avidor et al., 2020; Poowuttikul & Seth, 2020). It is evident that asthma self-management could be enhanced by apps to provide efficient interventions that lower treatment costs and improve patient's quality of life (Tinschert et al., 2017). A Previous cost-effectiveness study conducted on asthmatic patients , found no difference in cost between the new intervention and the paper-based treatment strategy (Van Der Meer et al., 2011). This is in line with recent study that assessed patient initiated care using apps for rheumatic arthritis patients (Seppen et al., 2023). However, the mean difference change in disease activity 28 (DAS28) was (-0.0.4 mean difference and 95, CI :0.39,0.30) and no significant change in cost (mean difference €514, 95 CI: -266,3690) from the new intervention compared to the old intervention. On the other hand, a study by Van De Hei et al.(2022) among difficult to-treat asthmatic patients has demonstrated that apps can be cost-saving in the asthma self-management, although there was no significant change in QALY. Regardless they have found that apps are cost-effective when applied to clinical case scenarios.

Apps are perceived to reduce costs on individual and in healthcare in countries with limited access to healthcare facilities, patient-facing applications also have the potential to lower costs by transferring some interventions from health facilities to patients' homes (Ambrosino & Fracchia, 2017). A systematic review of economic evaluations in other chronic diseases with high quality rated studies has shown that

the mobile health application is cost-effective in 29 studies(74%) ,economically benefiting and can save costs (Iribarren et al., 2017).

An ongoing clinical trial in the Netherland region of South Tyrolean team believes that self-management and shared decisions using apps reduce costs and improve care for patients and quality of life (Wiedermann et al., 2024). From the healthcare professional's standpoint, the provision of distant care has the potential to decrease expenses of asthma for individuals and the entire healthcare system, particularly in remote areas where access to healthcare is limited (Poowuttikul & Seth, 2020).

However, other studies have raised concerns that, though there is evidence that mobile applications could be cost-effective, it is difficult to generalize the effectiveness due to poor reporting and a lack of evidence (Avidor et al., 2020; Eze et al., 2020). Numerous authors have stated that one of the biggest challenges to assess economic viability in health management apps is heterogeneity of studies carried out, which includes a wide range of specializations, technologies ,applications, and actors(Bergmo, 2015).

Factors Affecting Users' Engagement in Apps

Previous works have identified several factors that affect active usage of mobile apps for asthma self-management. Wang et al. (2021) recognized 10 attributes that influence active usage of apps and classified them into three categories. They are: (a) excitement attributes (e.g., Design aesthetics, customization, and enjoyment) ;(b) performance attributes (e.g., sociability and social support) and;(c) basic attributes (e.g., Mobility, privacy, quality information etc.). The authors made the case that

through consumer satisfaction or dissatisfaction the three categories will have major impact on the active usage of applications.

As an illustration, Baldwin (2017) suggested that to increase users' engagement and adoption of apps, patient portals must have creative designs and intuitive features and inform patients of the need for further care, and provide results in plain language. For more details, see Table 2 below. Evidence also shows disparity in the usage of apps across different population groups; older people are not interested in apps, middle-aged adults are concerned about security and privacy, and young people are motivated by social media and more likely to use apps(Scholl & Sassenberg, 2021).

Table 1: Mobile apps attributes that influence users' engagement

SN	Characteristic	Definition	Source
1	Design attractiveness	The degree of attractiveness or beauty of a mobile health application's interface	(Baldwin et al., 2017; Y. Wang et al., 2021)
2	Adaptability	The extent to which mobile health application vendors customize their good for diverse customers	(W. Wang et al., 2024)
3	Satisfaction	The level of enjoyment or satisfaction customers derive from using mobile health application	(Wedel et al., 2024)
4	Mobility	The extent to which consumers can utilize applications irrespective of geographic location and the time of the day	(Anderson et al., 2016; Hong et al., 2008)
5	Sociability	The degree to which applications facilitate social engagement among consumers	(Almutairi et al., 2024)
6	Informational support	The extent to which mobile application offers information to address users' health problems	(Camacho-Rivera et al., 2020)
7	Emotional assistance	The extent to which healthcare providers and consumers use Apps to communicate their care and understanding to consumers	(Kagen & Garland, 2019)

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8	Feeling of security	The degree of protection that Apps provide for users' sensitive and private data	(Chen et al., 2018)
9	Technical ease of use	Consumers' evaluation of functionality, responsiveness, stability and accessibility of applications	(Anderson et al., 2016)
10	Quality of information	Consumers evaluation of timeliness, relevance, and accuracy of the data produced by the mobile health application	(Koyuncu & Ari, 2024; McLean et al., 2016)

Source*: Adapted from Journal of Medical Internet Research,2021:* Y.Wang,T.Wu,Z.Chen. Active Usage of Mobile Health Applications: Cross-sectional Study.

Barriers for Apps Use in Healthcare

Several challenges, impede the adoption of the technology in healthcare such as lack of system interoperability with electronic health records and other IT tools, a decreased in-person interaction between physicians and patients, and malfunctioning system that result in medical errors (Bonney, 2016). Concerns about liability, professionalism, and ethical issues, including privacy and confidentiality breaches are also some of the additional restrictions on the use of technology in healthcare (Poowuttikul & Seth, 2020).

One of the benchmark studies conducted in the United Kingdom ,that systematically assessed content for iOS and Android comprehensiveness ,compliance with the evidence-based asthma management and adherence to best practices found that nearly fifty percents of the appraised apps recommendations are not supported by the clinical guidelines(Huckvale et al., 2015).. Some apps that allows visualization and tracking of information such as allowing customers to put personal data to monitor symptoms or report peak flow and other related activities are susceptible to privacy breaches (Wu et al., 2015). Consequently, non-evidence-based apps are potentially dangerous when used as a medical tool(Buijink et al., 2013)

Previously, measuring the app quality was a major challenge, but the development of the Mobile Apps Rating Scale (MARS) in Australia, is a step in the right direction to standardize the measurement of app quality, and usability (Stoyanov et al., 2015). Studies have shown variability in quality among current apps, raising concern over self-management and clinical outcomes (Camacho-Rivera et al., 2020). A Current systematic review that evaluates the quality, functionality and alignment of the apps using Mobile Apps Rating Scale (MARS) tools confirmed that most of the apps lack quality and are not in line with guidelines (Robinson et al., 2024).

Additionally, oftentimes patients are reluctant to record their own symptoms scores when they are not sick, making it difficult to report the efficacy of the treatment to stakeholders (Kagen & Garland, 2019). Also, the use of apps and self-management of chronic diseases are ultimately impacted by disparities in health literacy, which disproportionately affect vulnerable populations (Hantgan & Jariwala, 2023). The advancement of apps in healthcare also runs the risk of causing the digital divide if it

ignores marginalized groups that are most in need of care in deprived communities (Pinnock et al., 2022).

Implementation and Integration of Apps into Healthcare

Interest in apps among policy-makers and physicians reflects their potential to support patients, health outcomes for self-management, and remote monitoring (Steinhubl et al., 2013). As reported by the European Commission Green Paper (2014), mHealth solutions applications can help medical professionals provide high-quality, reliable, and effective care wherever and whenever needed, while also enabling people to take a proactive and efficient approach to manage their own health.

However, major stakeholders such as legislators, insurers, and medical professional societies have refrained from formally endorsing apps due to a lack of clear strategy to evaluate and recommend apps to users (Singh et al., 2016). For this reason, Gordon and colleagues (2020) have suggested a framework that treats apps the same as medicine be prescribed through available workflows. However, there is an increasingly mounting concern about the effectiveness of the apps, or whether they meet patients' needs or in line with the available clinical guidelines (Camacho-Rivera et al., 2020; Huckvale et al., 2015). Furthermore, studies have raised concerns about the sustainability of app usage. In the majority of cases, patients tend to use the apps at the beginning but stop using apps over a period of time (Himes et al., 2019; Krebs & Duncan, 2015; Marcano Belisario et al., 2013). It is therefore necessary to evaluate the effectiveness of these patient-facing applications and their compliance with the available guidelines to ensure safe, effective, and efficient utilization.

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