Evaluation of the Healthy Air for Healthy Lungs Programme

Final Report

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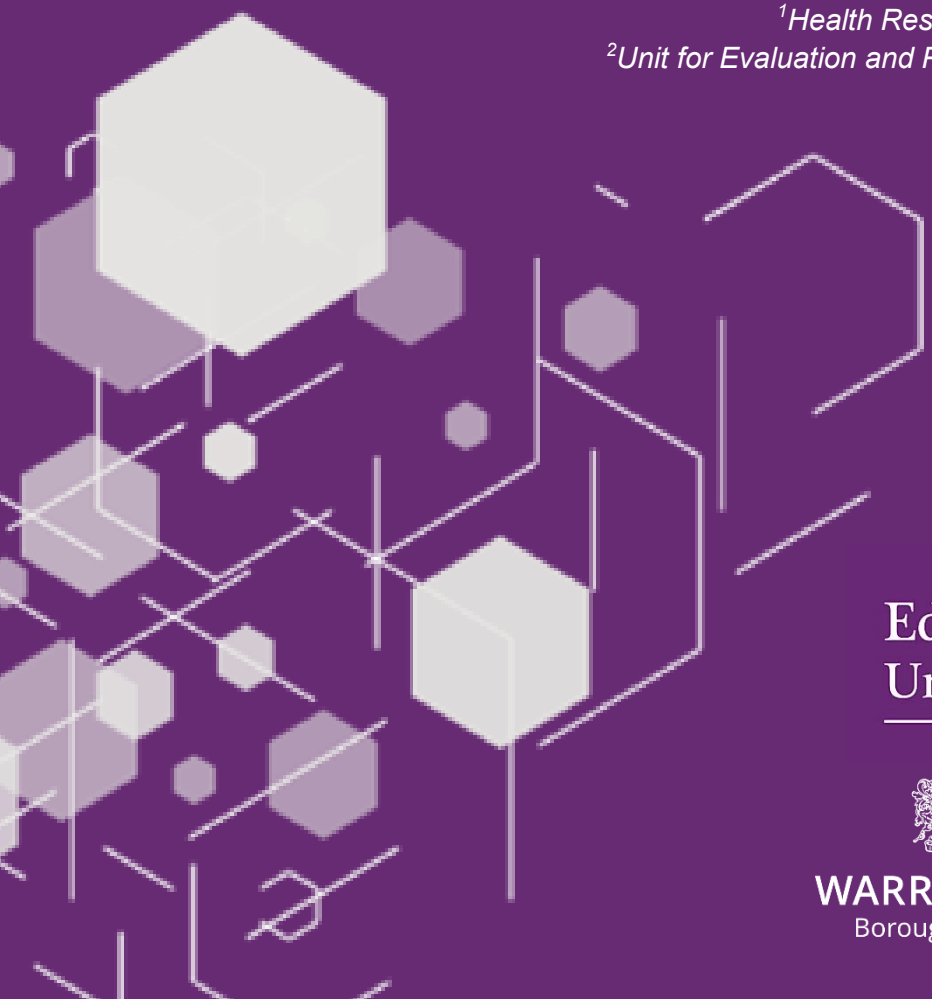

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ST HELENS BOROUGH COUNCIL

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Executive Summary

The Healthy Air for Healthy Lungs Programme was a two-year, DEFRA-funded initiative delivered across the St Helens and Warrington districts (Northwest of England). The programme aimed to improve respiratory health and wellbeing by reducing exposure to poor indoor air quality (IAQ) in homes where children experienced frequent respiratory symptoms. The target group included families with children aged two to ten who had recurrent use of reliever inhalers and underlying respiratory conditions. The programme sought to raise awareness of the risks of air pollution through in-home monitoring, tailored education, and practical behavioural support. The programme was delivered in participants' homes, where air quality monitors were installed to track indoor pollutants. Trained wellbeing staff visited households to explain the data, offer tailored advice, and support behaviour changes to reduce air pollution. Over a twelve-month period, participants received follow-ups every three months to review progress and reinforce learning. The model was later expanded to include community outreach and the provision of air purifiers or vouchers to sustain engagement. Recruitment began through general practitioner (GP) referrals but shifted to a broader community approach due to governance and data-sharing delays.

The evaluation of the programme was conducted using mixed methods. The evaluation aimed to assess the extent to which it achieved its intended outcomes, and to identify the conditions that supported or hindered success. Quantitative data were gathered from air quality monitoring devices, participant questionnaires, and programme delivery records. Qualitative data were collected through in-depth interviews with families and programme staff to explore experiences, perceived impacts, and contextual learning. The evaluation also conducted a secondary analysis of programme service survey data. Plans to link evaluation data with routine NHS health records were ultimately not realised due to regulatory barriers, limiting the ability to independently verify health outcomes, though self-reported household data did provide valuable insight.

The findings from the self-reported data show a mixed but largely positive impact for participating households. Although wellbeing measured by the World Health Organisation-5 did not show significant short-term change across the programme, qualitative interviews revealed that families consistently reported feeling more informed, confident, and in control of their home environments. More than half of the households interviewed described how they had gained a new understanding of the causes of poor indoor air quality and how to take practical steps to mitigate risks. The installation of air quality monitors was particularly felt to be positive as households were able to review live feedback on pollution levels in their own homes which raised awareness. This direct feedback empowered families to adopt small but meaningful

behavioural changes. Families frequently described how they had altered their behaviour to improve indoor air quality. Alongside these behavioural outcomes, families also described a perceived reduction in respiratory symptoms and the need for emergency healthcare. Many parents who were interviewed reported fewer visits to GPs for asthma-related issues and less reliance on inhalers over time. Notably, these accounts were self-reported and could not be validated against NHS utilisation data.

Analysis of indoor air-quality readings collected from participating households showed mixed trends across the six monitored indicators and no overall effect of the programme. For carbon dioxide (CO2), particulate matter (PM1 and PM2.5), and humidity, small but statistically significant increases over time were observed at the group level, although the size of these changes was modest and may not reflect meaningful deterioration in household environments. Temperature and volatile organic compounds (VOCs), by contrast, showed very slight downward trends, again with effects that were statistically detectable but small in magnitude. Together, these findings suggest that while indoor air-quality parameters fluctuated over the monitoring period, overall patterns of change were limited, and the data do not indicate substantial or systematic improvement or worsening across households. These results should be interpreted in light of the high variability in daily readings and the multifactorial context of the programme.

Our analysis with regard to implementation processes highlighted both barriers and enablers to the successful implementation of the programme. Key challenges included difficulties establishing data-sharing agreements with health partners, which delayed recruitment and limited access to eligible families. In addition, workforce turnover, capacity constraints, and operational demands further limited the efficiency of programme delivery. In some areas, inconsistent communication reduced visibility and local ownership of the programme. Despite these challenges, several enabling factors supported effective delivery. The commitment and motivation of the delivery staff were repeatedly emphasised by families as critical to their positive experience. The relational, trust-based approach helped families engage openly and act on advice. In addition, strong leadership and collaboration between local authority teams and community partners created an environment conducive to innovation and adaptation.

Our findings indicate that the programme model has potential for wider replication as an equitable, community-based approach to improving respiratory health. The analysis supports the interpretation that the intervention’s primary impact, at this stage, may be perceptual, rather than environmental. As such, the evaluation is best understood as formative, that is testing feasibility, acceptability, and mechanisms of change, rather than identifying clear causal mechanisms of effect.

The evaluation resulted in eight recommendations for future programme development and research:

1. Put data-sharing and referral arrangements in place before the programme begins, so information can be shared smoothly between the programme partners, the NHS, and evaluation partners.
2. Use study designs that track change over time or compare groups (e.g., quasi experimental) to better understand whether the programme is contributing to changes in health or air quality.
3. Collect air-quality data across different seasons and housing types (e.g., older and newer builds), to help distinguish programme effects from normal day-to-day or seasonal variation.
4. Use established tools to measure behaviour change, so changes in household practices can be assessed more consistently.
5. Treat future programmes as opportunities for learning and improvement, focusing on what works, what can be refined, and how communities engage.
6. Design eligibility and recruitment criteria that can be adapted locally, allowing the programme to respond to different community needs and housing contexts.
7. Clearly define and standardise the education and support offer within the programme, combining air-quality feedback with practical, tailored advice for households.
8. Improve local visibility and ownership by aligning branding and communications across boroughs, ensuring the programme feels relevant and accessible in all areas.

Background

The Healthy Air for Healthy Lungs Programme represented an innovative, multi-agency response to the growing evidence linking indoor air quality (IAQ) with respiratory ill health (in children). Commissioned by the Department for Environment, Food and Rural Affairs (DEFRA), the programme aimed to improve indoor environmental conditions in households with children who experience recurrent respiratory symptoms (particularly asthma). It combined environmental monitoring, public education, and behaviour change components which were delivered through a community-based intervention.

The programme operated across two boroughs of St Helens and Warrington, both of which exhibit higher-than-average rates of asthma and respiratory-related health inequalities. The programme was implemented through a collaboration between local public health teams (St Helens and Warrington Borough Councils), City Healthcare Partnership, and a network of local voluntary and community organisations.

National Context and Policy Drivers

Air pollution remains a key environmental threat to health in the United Kingdom (PHE, 2018). The 2019 Clean Air Strategy, published by DEFRA, identifies air pollution as the top environmental risk to health, contributing to a wide range of adverse outcomes including cardiovascular and respiratory diseases, cancer, and reduced life expectancy (DEFRA, 2023). Although much of the national discussion has focused on outdoor air pollution, increasing attention is being paid to indoor environments, where families (particularly children) spend most of their time.

The NHS Core20PLUS5 framework, which prioritises reducing health inequalities, explicitly identifies respiratory health as a key area of focus (NHS England, 2023). Children from deprived areas, who are more likely to live in homes with dampness, poor ventilation, or exposure to pollutants, are disproportionately affected (Holden et al, 2023). In addition, the Environment Act 1995 places statutory duties on local authorities to assess and manage air quality within their jurisdictions (HM Government, 1995). This includes designating Air Quality Management Areas (AQMAs) where national objectives for pollutants are often exceeded (DEFRA, 2023).

Local Context

The Cheshire and Merseyside Integrated Care System (ICS), which encompasses both St Helens and Warrington, reports asthma prevalence rates of 7.0% among residents aged six and above, compared to the national average of 6.5% (Asthma, Lung UK, 2022). Within the region, respiratory diseases remain among the leading causes of premature mortality and health service utilisation. In addition, the Northwest

of England also exhibits some of the highest levels of socio-economic deprivation nationally, with corresponding disparities in respiratory outcomes (ONS, 2023).

Poor air quality, both indoor and outdoor, contributes disproportionately to ill health among low-income households (Holden et al, 2023). Deprived communities are more likely to reside in housing with poor insulation, inadequate ventilation, or high humidity, and may rely on domestic burning (e.g., solid fuels, wood stoves) (The Health Foundation, 2024). These factors compound the respiratory risks associated with poor indoor air quality (often worsened by smoking, dampness, and overcrowding). St Helens is one of the most deprived areas in England, currently ranked 46th most deprived local authority out of 317 (NHS Cheshire and Merseyside, 2025). Approximately 40% of its residents live within the top 20% most deprived national deciles, and nearly one-third of local children live in poverty (UK Government IMD, 2025). The borough faces long-standing challenges related to respiratory health; as asthma admissions in children under 19 years exceed national rates.

In response to this, the borough declared four Air Quality Management Areas (AQMAs) due to breaches in NO2 limits, largely associated with major road networks such as the M6 corridor (St Helen Borough Council, 2024). While recent status reports demonstrate gradual improvement, exposure hotspots remain, particularly in areas of high deprivation and older housing (St Helens Borough Council, 2025). The Warrington region also faces similar air quality challenges. Two AQMAs have been declared: one covering a 50-metre buffer around the motorway network, and another encompassing the town centre and major access roads (Warrington Borough Council, 2025). Local sources of pollution include transport emissions, industrial activities, and domestic heating, alongside regional and transboundary contributions from beyond borough boundaries.

The Problem of Indoor Air Quality

Indoor environments contain a complex mixture of pollutants derived from both outdoor infiltration and indoor sources. Particulate matter (PM1 and PM2.5), volatile organic compounds (VOCs), nitrogen dioxide (NO2), carbon dioxide (CO2), and humidity interact to create a risk to ill health (Meo et al, 2024). These pollutants originate from multiple sources such as cooking, cleaning products, smoking, vaping, scented candles, damp housing materials, and domestic heating (particularly wood burning) (Meo et al, 2024). There is strong evidence linking indoor air pollution to respiratory morbidity, especially in children (Raju et al, 2020). In both St Helens and Warrington, a combination of environmental, social, and structural factors creates conditions conducive to poor indoor air quality. The presence of widespread Smoke Control Areas (SCAs) in both boroughs underscores the local commitment to controlling emissions, yet compliance and enforcement remain variable. The cost-of-living crisis has intensified reliance on low-cost solid fuels, exacerbating household-level exposure risks (Jiang et al, 2024). In addition, local housing stock is old and often

poorly insulated, which contributes to dampness and limited ventilation. These conditions are known to aggravate asthma symptoms and increase susceptibility to respiratory infections, particularly among children (Holden et al, 2023).

The Healthy Air for Healthy Lungs Programme

In response to the local and national challenges, St Helens Borough Council and Warrington Borough Council secured DEFRA funding to implement a two-year indoor air quality improvement programme. The initiative was designed to complement existing Air Quality Action Plans (AQAPs), while expanding their remit to address the often-overlooked indoor dimension of air pollution. The programme aligns directly with the councils' statutory responsibilities under the Environment Act 1995 and contributes to local strategies such as the St Helens Borough Strategy and the Warrington Air Quality Action Plan (both of which prioritise reducing emissions, improving health, and promoting community awareness).

Programme Aims

1. Monitoring indoor air quality in households where people are at increased risk of exacerbation of respiratory disease and adverse effects from air pollutants (such as CO2, relative humidity, temperature, PM1, PM2.5, and volatile organic compounds - VOC).
2. Raising awareness of how to improve indoor air quality through targeted education and campaigns.
3. Raising awareness of the impact of domestic burning on indoor air quality and respiratory conditions.

Programme Objectives

1. Reduce levels of indoor air pollution from specific pollutants, especially particulate matter (PM1 and PM2.5).
2. Raise household awareness about indoor air quality
3. Change household behaviours towards practices such as smoking and vaping, and domestic burning.
4. To minimise pollutants from smoking and vaping inside the house, burning the wrong fuel type by giving advice on what should and shouldn't be burned on log burners and open fires, scented candles, and cooking smoke
5. Measure the impact of targeted education and awareness on behaviour and people's ability to improve their indoor air quality.
6. Measure Parental Wellbeing using the WHO-5 wellbeing questionnaire

7. Improve asthma related outcomes in the households as reported by patients and/or clinicians.

Target Population

The programme specifically targeted households within St Helens and Warrington with children aged 2 to 10 years who have been prescribed three or more salbutamol inhalers within the previous year.

Programme Recruitment and Engagement

Initial recruitment utilised NHS digital systems to invite eligible families via their GP practices. However, recruitment later reverted to direct referrals from respiratory hubs, social prescribing teams, and local voluntary networks such as Breath Buddies and Parent Champions.

The programme employed health trainers and wellbeing workers who conducted home visits, installed monitoring devices, and provide personalised feedback based on real-time data. Engagement workshops held in community venues extended the programme's reach, enabling residents to learn about IAQ, interact with devices, and register to take part. The programme set out to recruit 500 households across St Helens and Warrington.

Programme Delivery

The Healthy Air for Healthy Lungs Programme was delivered through a structured series of home visits and follow up telephone calls designed to support behaviour change and track improvement over time. The graphic below indicates the programme recruitment and delivery pathway.

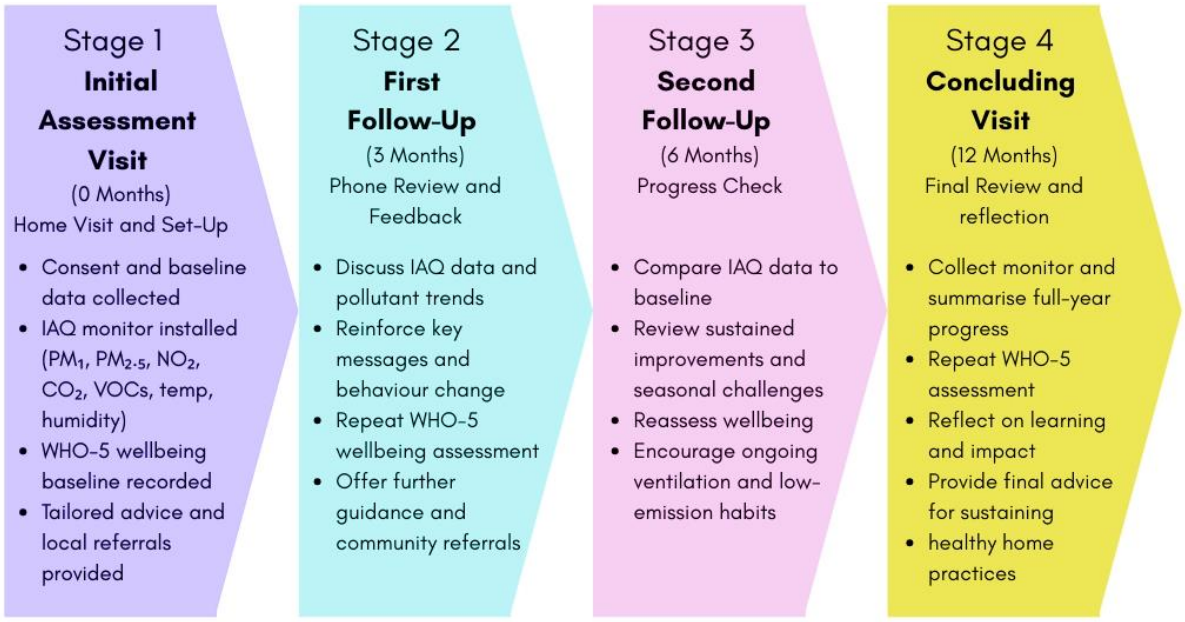


Figure 1. Programme delivery

Initial Assessment Visit

The initial visit formed the foundation of the intervention and typically took place within two weeks of participant referral. Practitioners obtained informed consent, explained the programme scope, and gathered baseline information on household characteristics and occupant wellbeing. Practitioners recorded data on ventilation, heating, and potential indoor pollutant sources.

Indoor air quality (IAQ) monitors (AirThings) were installed to measure key indicators including PM1, PM2.5, NO2, CO2, VOCs, temperature, and humidity, with data transmitted to a central dashboard (AirThings Dashboard) for ongoing monitoring. Baseline wellbeing was assessed using The World Health Organisation-5 Well-Being Index (WHO-5). The visit concluded with tailored education and advice on reducing exposure to indoor pollutants and referrals to relevant local services such as smoking cessation, energy efficiency, and housing support schemes.

First Follow-Up (Three Months)

Approximately three months after the baseline visit, practitioners conducted the first follow-up via telephone to provide households with feedback from their IAQ monitors. Data were reviewed with participants to highlight pollutant patterns and identify possible sources, helping translate technical findings into practical actions. Practitioners also reassessed wellbeing using the WHO-5. The visit reinforced the initial guidance, offered targeted behavioural advice, and used motivational interviewing to sustain commitment to change. Practitioners also provided further

signposting to local wellbeing and community support services, addressing persistent environmental issues such as damp or inadequate ventilation.

Second Follow-Up (Six Months)

The second follow-up, conducted around six months after enrolment, served to consolidate earlier progress and assess medium-term outcomes. IAQ data were compared with baseline results to evaluate reductions in pollutants and improvements in home conditions. Practitioners repeated the IAQ assessment and reassessed wellbeing using WHO-5. At this stage, education and training focused on maintaining improvements, addressing seasonal challenges, and promoting advanced strategies (e.g., safe domestic burning and use of low-emission household products).

Concluding Visit (12 Months)

The final visit marked the completion of the intervention, approximately 12 months after the initial assessment. Practitioners decommissioned and collected the monitoring equipment and reviewed the final IAQ data with participants, providing a summary of changes since baseline. The WHO-5 assessment was repeated to capture longitudinal change, and participants were invited to reflect on their experiences, perceived benefits, and remaining challenges. Final educational guidance was provided to help households sustain improved practices. Households were encouraged to remain engaged with local wellbeing and community networks.

Programme Logic Model

The evaluation team worked with the Healthy Air for Healthy Lungs Programme team to undertake a logic model workshop. The purpose of the workshop was to clarify programme goals and intended outcomes. The output from the logic model workshop can be seen in appendix A.

Programme Developments - Adaptations of Programme

The Healthy Air for Healthy Lungs Programme was implemented with strong fidelity to its core model while demonstrating substantial adaptive capacity throughout delivery. However, several adaptations were introduced that enhanced the feasibility, reach, and engagement. These adaptations reflected a responsive implementation culture, enabling the programme to remain effective and contextually relevant within the operational realities of local government and health system settings.

Figure 2. Adaptations to programme delivery

Adaptations to Recruitment Strategies

Recruitment represented the area of greatest adaptation of the programme. Initial plans to identify participants through NHS and GP referral pathways proved unfeasible due to stringent data governance requirements and delays in securing data-sharing agreements. In response, the implementation team pivoted to a mixed recruitment model that combined community outreach, local authority channels, and self-referral routes. This shift was widely viewed as a turning point that safeguarded the programme's viability and ensured a steady flow of participants (despite initial barriers).

In St Helens, recruitment adaptations were refined to reflect geographical and housing realities. The original plan focused on families living within air quality management

areas; however, these zones contained few residential properties, limiting the pool of eligible participants. The team responded by expanding eligibility to include families borough-wide, while maintaining a focus on those affected by respiratory illness. A similar approach was adopted in Warrington, where eligibility criteria were also widened to enable recruitment beyond air quality management areas. This pragmatic adjustment improved recruitment efficiency and allowed for broader community inclusion without undermining the programme's environmental health objectives. These adaptations were seen as both strategic and instructive, demonstrating how programme design can evolve in real time to address contextual challenges, while maintaining the core aims of the programme.

Adaptations to Engagement and Incentive Models

As recruitment stabilised, further adaptations were introduced to strengthen participant engagement and retention. Midway through implementation, the incentive model was revised to include an option for families to receive air purifiers in addition to or instead of monetary vouchers. This modification responded directly to participant feedback and was described by stakeholders as an effective way to sustain motivation, reinforce the health message of the intervention, and provide an immediate tangible benefit.

Regular follow-up visits, originally designed to occur every three months, were also adapted to allow for more flexible scheduling, accommodating family availability and staffing capacity (often by telephone). These adjustments helped sustain participation over the 12-month monitoring period and improved the quality of interactions between delivery staff and families. The iterative use of participant feedback to refine engagement processes exemplified the programme's commitment to adaptive learning and continuous improvement.

Adaptations to Governance, Staffing, and Operational Delivery

Operational and governance-related adaptations were equally important. Early implementation was slowed by delays linked to GDPR compliance, data-sharing approvals, and procurement procedures. To address these challenges, programme leads established closer working relationships with NHS partners and developed clearer internal processes for handling data and consent. These adjustments streamlined administrative procedures and ensured ethical and legal compliance while maintaining momentum.

Leadership transitions during the programme also necessitated adaptive management. When key staff members departed, new leads undertook efforts to rebuild partnerships and re-establish delivery routines. Stakeholders reported that these transitions, though initially disruptive, prompted clearer communication pathways, better documentation, and more structured decision-making.

What We Have Done

The evaluation of the Healthy Air for Healthy Lungs Programme employed a mixed methods design to assess the impact of the programme. The evaluation was designed to ensure the insights generated could inform future practice and policy.

Primary Objective of Evaluation

To determine the effectiveness and feasibility of the indoor air quality (IAQ) programme on asthma-related outcomes among children and young people in St Helens and Warrington.

Secondary Objectives of Evaluation

1. Assessing changes in indoor air pollutant levels (e.g., PM1, PM2.5, VOCs) before and after the intervention.
2. Evaluating the impact of education on awareness and behavioural changes in households, particularly around domestic burning and ventilation practices.

Evaluation Outcomes

We anticipated two outcomes of the evaluation. First, findings from the analysis of a baseline and follow-up Monitoring of Indoor Air Quality Data which would indicate changes in pollutant levels pre- and post-intervention. Second, we aimed to capture behavioural change based on increased awareness of the impact of air quality on health.

Data Collection

Our data collection activities comprised four different domains. The graphic below gives an overview and provides additional details on evaluation tasks conducted in each domain.

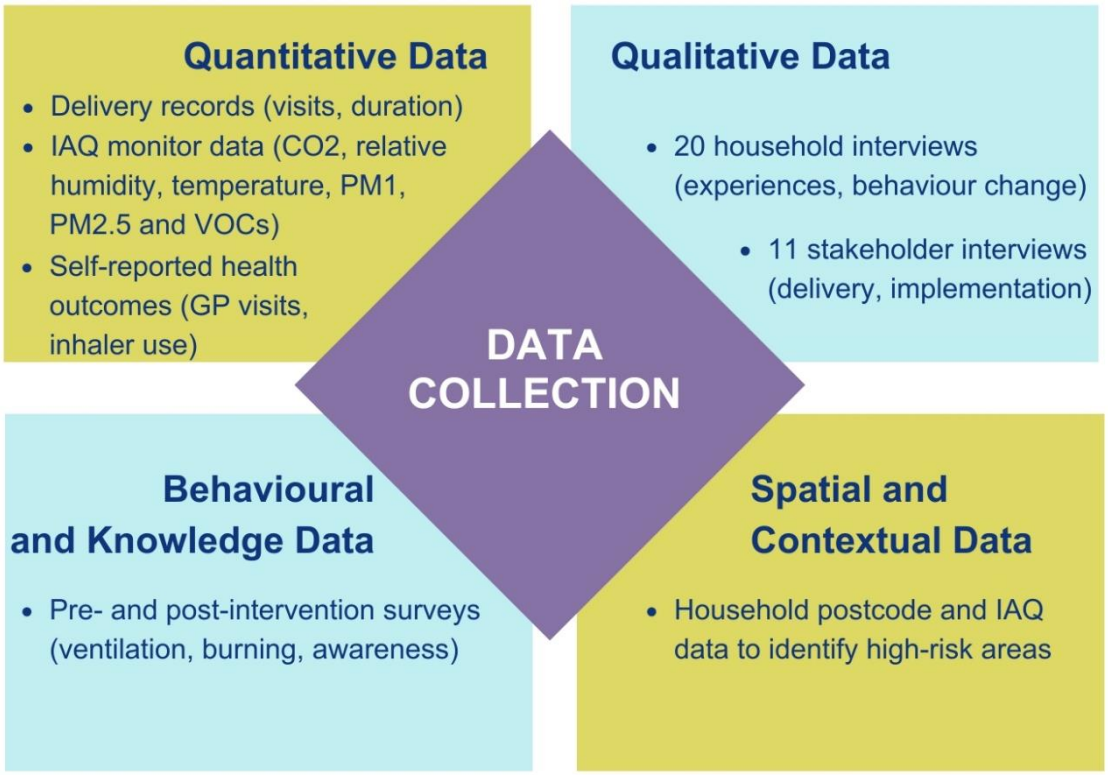


Figure 3. The range of data collected and analysed during the evaluation

Quantitative data from delivery records, such as the number of households engaged and the number of visits, provided a descriptive account of the programme. Programme service data were analysed including data captured with the WHO-5 instrument. GP visits, inhaler use, and hospital attendances were captured by the programme using a self-reported survey. We conducted a secondary analysis of these data. Indoor air quality was assessed using continuous monitoring data from AirThings devices installed in participating households. Pollutant concentrations were analysed for changes in mean levels, peaks, and time spent above recommended thresholds (pre and post intervention).

Qualitative data were gathered through semi-structured interviews with 20 households who participated in the programme. In addition, semi structured interviews were conducted with 11 programme delivery stakeholders. Interviews with households and stakeholders explored household experiences, acceptability of the intervention, perceived impact, changes in awareness and behaviour, and perceived barriers and enablers to implementation.

Behavioural change and knowledge assessment was conducted using a survey with households specifically relating to indoor air quality management (e.g., ventilation, burning etc). Surveys were conducted pre- and post-intervention at baseline, and 12-

month follow-up. The quantitative dataset was supplemented with qualitative interview data obtained from participating households, providing a richer contextual understanding of the findings. However, the study was unable to incorporate health outcomes analysis via the CIPHA platform, as approval for access to this resource was not granted by the NHS.

Data Analysis

Data analysis incorporated both quantitative and qualitative approaches to provide a comprehensive understanding of programme outcomes.

Indoor air quality monitoring data from the AirThings devices (CO2, relative humidity, temperature, PM1, PM2.5 and VOCs) were extracted at the level of individual measurements and then aggregated to create one observation per household per day. For each pollutant, we calculated daily summary statistics (mean, median, minimum, maximum, standard deviation and number of readings) for every participating household-day. To examine overall trends in indoor air quality over the monitoring period, we constructed simple linear regression models with the daily mean pollutant concentration as the dependent variable and time (expressed as the number of days since the start of monitoring for each household) as the independent variable. This approach provided an estimate of the average change in pollutant levels over time across all households. Given the large volume of raw sensor readings, regression analyses were conducted on the aggregated daily dataset rather than the full high-frequency time series. Model diagnostics (inspection of residual plots and significance of regression coefficients) were used to assess linearity, variance and overall model fit, with statistical significance defined as $p < 0.05$.

Qualitative data were analysed thematically following Braun and Clarke's framework, which facilitated an in-depth exploration of participant experiences, and contextual factors influencing effectiveness (Braun and Clarke, 2021). The analysis also examined mechanisms of change, such as how enhanced awareness and modified household practices associated to reductions in pollutant exposure.

What We Have Found

We have structured the report in the following way. First, we report household characteristics of programme beneficiaries. Second, we provide the findings from our analysis of air quality monitoring. Third, we report insights from a secondary analysis of programme service data collected by programme staff. And fourth, we detail the findings of our analysis of interviews with programme beneficiaries.

Household Characteristics

The dataset comprised 221 households in which partial postcode data were available for analysis. Households were distributed across 59 postcode sectors within the WA postcode area, covering parts of Merseyside and Cheshire. The most frequent postcode districts were WA9 (69 households; 31.1 %), WA10 (34; 15.3 %), WA12 (20; 9.0 %), WA5 (17; 7.7 %), and WA11 (16; 7.2 %), largely situated in the St Helens Borough. Together, these five postcode districts accounted for 70 % of all households. The remaining 30 % of households were distributed across WA1, WA2, WA3, WA4, and WA13, predominantly in Warrington.

Combining partial postcode and approximate Index of Multiple Deprivation (IMD) data, around two-thirds of all participating households were situated in boroughs characterised by high deprivation, while one-third resided in boroughs with moderate or low deprivation (average estimates from LSOA's within partial postcode sectors) (see Table 1).

Table 1. Household characteristics

Partial Postcode	Borough / Local Authority	Index of Multiple Deprivation (approx. national decile)	Households	% of Sample
WA9	St Helens (Merseyside)	High deprivation (decile 2)	69	31.1 %
WA10	St Helens (Merseyside)	High deprivation (decile 2)	34	15.3 %
WA12	St Helens (Merseyside)	High deprivation (decile 2)	20	9.0 %
WA11	St Helens (Merseyside)	High deprivation (decile 2)	16	7.2 %
WA5	Warrington (Cheshire)	Moderate (decile 4–5)	17	7.7 %
WA4	Warrington (Cheshire)	Low-to-moderate (decile 5–6)	13	5.9 %
WA2	Warrington (Cheshire)	Moderate (decile 5)	12	5.4 %
WA1	Warrington (Cheshire)	Moderate (decile 5)	10	4.5 %
WA3	Warrington (Cheshire)	Moderate (decile 5)	4	1.8 %
WA13	Warrington (Cheshire)	Lower deprivation (decile 7)	4	1.8 %

Impact Evaluation

Analysis of Air Quality Monitoring Data

Daily air-quality readings were aggregated to produce one mean value per individual household per day, following removal of missing observations. Trend analyses were conducted using simple linear regression, with *number of days since monitoring began* as the predictor variable. This allowed us to assess whether air-quality indicators showed improvement or deterioration over the course of the programme.

Overview of findings from the analysis

This section presents findings from the analysis of indoor air-quality monitoring data collected during the programme. A key finding was that average pollutant levels across households did not change substantially over the monitoring period. Some indicators showed small changes over time, with only slight reductions observed for carbon dioxide (CO2) and volatile organic compounds (VOCs), and only modest increases for humidity and fine particulate matter (i.e., PM1 and PM2.5). While several of these trends were statistically significant, the degree of change was small. The section below report results for each of the six environmental measures in detail.

Carbon Dioxide (CO2)

After cleaning and data aggregation, 1,563 daily CO2 observations remained. Mean CO2 concentration across the programme period was 798.7 ppm. Regression analysis showed a statistically significant downward trend in CO2 over time ($F(1,1561)=25.04$, $p<.001$). However, the effect size was small ($R^2=0.016$), indicating that only 1.6% of the variance in CO2 levels was explained by time. The slope coefficient ($B = –0.647$, $p<.001$) indicates that CO2 decreased by approximately 0.65 ppm per day. Although statistically significant, this decline is modest and suggests that day-to-day variation was influenced by other household or environmental factors.

Humidity

Daily mean humidity values were calculated for 1,563 household-days. Average relative humidity was 55.1% (SD = 7.56%). A significant upward trend was observed over time ($F(1,1561)=145.78$, $p<.001$). Time accounted for 8.5% of the variance in humidity ($R^2=0.085$). The slope ($B = 0.045$, $p<.001$) indicates that Humidity increased by 0.045 percentage points per day. This represents a small but consistent rise (≈1.35 percentage points per month). In practical terms, homes had average humidity levels

of around 55%, with humidity rising slowly but steadily over the monitoring period. Although the increase was small, the trend was consistent and statistically significant.

PM1 (Fine Particulate Matter ≤1 µm)

Following data aggregation, 1,558 daily PM1 observations were available. The regression model showed a significant increasing trend ($F(1,1556)=44.72$, $p<.001$). Time explained 2.8% of variance ($R^2=0.028$). The slope coefficient ($B = 0.076$, $p<.001$) indicates that PM1 increased by 0.076 µg/m³ per day. Although the effect size is small, the direction is consistent with a gradual deterioration in PM1 levels during the monitoring period.

PM2.5 (Fine Particulate Matter ≤2.5 µm)

A total of 1,558 aggregated PM2.5 observations were analysed. Results showed a significant upward linear trend ($F(1,1556)=46.40$, $p<.001$), with $R^2=0.029$. The time coefficient was positive ($B = 0.081$, $p<.001$) which indicates that PM2.5 increased by 0.081 µg/m³ per day. As with PM1, this represents a small but statistically reliable increase over time.

Volatile Organic Compounds (VOCs)

After aggregation, 1,558 daily VOC observations were retained. A very small but statistically significant downward trend was detected ($F(1,1556)=4.67$, $p=0.031$), with time explaining only 0.3% of variation ($R^2=0.003$). The slope was negative ($B = –0.221$, $p=0.031$) which indicates that VOC concentrations decreased by 0.22 ppb per day. The trend is statistically detectable, but very small in magnitude.

Temperature

Daily mean temperatures yielded 1,563 aggregated observations. The mean indoor temperature was 22.14°C (SD = 2.27). A significant downward trend over time was detected ($F(1,1561)=79.91$, $p<.001$), with $R^2=0.049$. The slope ($B = –0.009$, $p<.001$) indicates that temperature decreased by 0.009°C per day. This equates to approximately 0.27°C per month which is a small but consistent change.

Summary of Trends Across All Measures

Measure	Direction of Trend	Size of Effect	Interpretation
CO**2**	↓ significant	Very small	Slight improvement in ventilation/air turnover
Humidity	↑ significant	Small	Gradual rise in moisture levels
PM1	↑ significant	Very small	Slow increase in fine particulates
PM2.5	↑ significant	Very small	Slow increase in fine particulates
VOCs	↓ significant	Very small	Minor improvement in volatile compounds
Temperature	↓ significant	Small	Gradual decline in indoor temperature

Overall, all trends were statistically significant, but effect sizes were small in nearly all cases, reflecting the natural variability of indoor environments and a modest programme impact detectable within the study timeframe.

Secondary Analysis of Programme Service Data

The evaluation obtained programme service data that captured outcomes through a survey of participants. The following analysis is based on secondary analysis of the programme service data.

Wellbeing Related Outcome

The WHO-5 index was used to measure participant wellbeing (focused on components of mental wellbeing). The WHO-5 Index is a brief self-report measure of well-being (over the past two weeks), comprising five items which are scored 0 to 5 (a higher score translates to better perceived wellbeing). A percentage score below 50 percent, or a raw score below 13, has been suggested as a cut-off for poor well-being (an indication for further assessment).

At baseline, 58 households completed the WHO-5 questionnaire, had a mean well-being score of 16.53 (SD = 3.40). This value indicated a moderate level of self-reported psychological well-being across households, somewhat above the poor wellbeing cut off score of 13. At subsequent follow-up points, data availability decreased due to attrition: 51 households at 3 months, 23 at 6 months, 15 at 9 months, and only 4 at 12 months. Across all timepoints, mean WHO-5 scores remained broadly stable, fluctuating within a narrow range between approximately 13 and 18 points. The

reduction in available paired observations over time - particularly after 6 months - limited the statistical power to detect small or moderate changes in well-being.

Baseline vs. 3-Month Follow-Up

Among the 49 participants with paired baseline and 3-month data, the mean WHO-5 score increased from baseline by 0.43 points (SD of difference = 4.64). The paired t-test yielded t(48) = 0.65, p = 0.521, indicating that this small improvement was not statistically significant. Descriptively, the distribution of changes showed a mix of small increases and decreases across households, with no systematic pattern. These results indicate that, on average, participants' well-being remained stable during the initial 3 months of the intervention.

Baseline vs. 6-Month Follow-Up

For the 23 households providing data at both baseline and 6 months, the mean WHO-5 score increased by 1.43 points (SD = 4.26). The paired t-test produced t(22) = 1.61, p = 0.121, indication no statistical significance in scores. The effect size was Cohen's *d* = 0.34, which corresponds to a small-to-moderate magnitude of improvement. Although not statistically significant at the 0.05 level, this trend suggests that participants may have experienced small positive changes in their perceived well-being by the mid-point of the study.

Baseline vs. 9-Month Follow-Up

At 9 months, paired data were available for 15 households. The mean difference between 9-month and baseline WHO-5 scores was only +0.33 points (SD = 6.04), with the paired t-test indicating no statistical significance in scores between the timepoints t(14) = 0.21, p = 0.834. The effect size was Cohen's *d* = 0.06, indicating a negligible effect. While a small number of households reported slight improvements, others showed stable or lower scores. Overall, there was no indication of systematic change in well-being by this stage of the intervention. The variability in scores (reflected in the large SD) suggests increased heterogeneity in individual experiences of well-being, possibly influenced by contextual or seasonal factors rather than intervention effects.

Baseline vs. 12-Month Follow-Up

Only four participants provided both baseline and 12-month data, resulting in a highly underpowered comparison. The mean WHO-5 score at 12 months was 2.00 points lower than baseline (SD of differences = 6.78), however the small sample size makes it impossible to determine whether this decline reflects genuine change, random variation, or differences in the subset of households that remained engaged over 12 months. The estimated Cohen's *d* = −0.29 represents a small effect, but with so few observations, this result cannot be meaningfully interpreted.

Overall Pattern Across Timepoints

Taken together, these analyses demonstrate that no statistically significant changes in WHO-5 scores were detected at any follow-up point compared to baseline ($p > 0.05$). The direction of change was slightly positive at 3, 6, and 9 months, with the largest (though non-significant) improvement observed at 6 months. By 12 months, scores appeared to decline marginally, but data were too limited to draw conclusions. Across all comparisons, effect sizes were small, indicating that any differences in well-being were modest.

Descriptively, the pattern suggests that participants' subjective well-being remained broadly stable over the 12-month period. The absence of detectable change may indicate that the indoor air quality intervention did not substantially influence mental well-being, or that any benefits were offset by other social or environmental factors. However, the progressive reduction in sample size limits the ability to detect subtle but potentially meaningful changes (follow-up completion beyond six months was particularly low).

Summary of Findings

Across the full 12-month evaluation period, WHO-5 well-being scores among participating households showed no statistically significant changes relative to baseline. Although mean scores tended to increase slightly at the 3 and 6-month follow-ups, these differences were small in magnitude and did not reach conventional thresholds for statistical significance. By 9 months, scores had returned to near-baseline levels, and by 12 months, the limited number of available paired observations (n = 4) prevented analysis.

Respiratory Related Outcomes

Self-Reported GP Visits Among Participating Households

A total of 57 households provided complete data for both timepoints. At baseline, households reported an average of 4.28 (± 3.58) child GP visits in the previous 12 months. At the 12-month follow-up, the average was 1.32 (± 2.33) visits. The median values were 4 and 0, respectively, indicating a substantial shift toward fewer GP visits following the intervention.

The mean paired difference (follow-up minus baseline) was −2.96 (± 3.43) visits per household-year, corresponding to an average reduction of nearly three visits. Approximately three-quarters of households (75.4 %) reported a decrease in GP visits, while 3.5 % reported an increase and 21 % reported no change.

The paired t-test demonstrated a statistically significant reduction in GP visits from baseline to follow-up ($t(56) = -6.53$, $p < 0.001$). These results suggest a statistically and practically significant decline in self-reported child GP visits over 12 months among participating households. However, this should be interpreted with caution given the substantial proportion of missing follow-up data (74 % of the original sample), and potential recall bias in self-reported counts.

Self-Reported Hospital Admissions Among Participant Households

At baseline, the number of hospital attendances per household over the preceding 12 months ranged from 0 to 11 (M = 1.80, SD = 2.79) (paired data from 58 households). During the 12-month intervention period, attendances ranged from 0 to 30 (M = 1.02, SD = 4.19). The mean paired difference between follow-up and baseline was −0.79 attendances (SD = 4.71), indicating a general reduction in hospital use across the sample, though substantial variability was observed between households.

A paired samples t-test indicated that this reduction was not statistically significant, t(55) = −1.25, p = 0.217. The corresponding 95% confidence interval for the mean difference was [−2.05, 0.48], and the effect size was small. Despite the lack of statistical significance, the direction of change was consistent in that most households experienced the same or fewer hospital attendances during the intervention year compared with the previous year, while only a few reported increases.

Overall, these findings indicate that participation in the indoor air quality improvement intervention could be associated with a reduction in hospital attendances. Although the average decrease (approximately one fewer attendance per household) was modest and statistically non-significant, it represents a potential shift, given the multifactorial nature of hospital utilisation.

Self-reported Number of Inhalers Prescribed Among Participating Households

Among the 56 households with complete data, the mean number of inhalers prescribed in the 12 months prior to the intervention (baseline) was 11.66 (SD = 8.01), with a median of 10 and an interquartile range (IQR) of approximately 5 to 18 inhalers. During the 12-month intervention period, the mean number of inhalers prescribed decreased to 8.91 (SD = 7.60), with a median of 6 and an IQR of roughly 4 to 12 inhalers. The mean change (12-month minus baseline) was −2.75 inhalers, indicating that households received, on average, nearly three fewer inhalers during the intervention year.

A paired-samples t-test comparing baseline and 12-month inhaler counts demonstrated a statistically significant reduction following the intervention ($t(55) = 2.5385$, $p = 0.0140$). The mean difference (12-month − baseline) was −2.75 inhalers, and the 95% confidence interval ranged from −4.873 to −0.627 inhalers. These results indicate a statistically significant reduction in inhaler prescriptions at 12 months compared with baseline, suggesting a potential beneficial effect of the intervention among households with complete data.

While these findings suggest the intervention may have helped reduce the need for inhalers, many households did not have follow-up data, so the results should be interpreted with some caution.

Findings from Interviews

Self-Reported Impact on Overall Health

Most families described two key types of impact following their participation in the Healthy Air for Healthy Lungs Programme. More than half of households reported noticeable physical improvements, such as fewer day-to-day respiratory symptoms. Alongside these physical benefits, families also highlighted some psychological benefits, including a greater feeling of control over their home environment, and renewed motivation to manage asthma more effectively. However, this was not felt universally as a smaller number of families reported no clear change or an uncertainty about whether improvements were due to the programme itself or to other factors such as seasonal variation.

Physical Health Benefits

More than half the families interviewed described noticeable improvements in their children's respiratory health following participation in the programme. Parents spoke of fewer asthma flare-ups, reduced inhaler use, and a decline in the need for GP or hospital visits. Several attributed these improvements to practical changes they had made at home, particularly increased ventilation, and reduced use of strong cleaning products. For many households, these adjustments were described as small but meaningful shifts that led to more stable breathing patterns and fewer symptoms over time. One parent reflected,

> *"To be completely honest, I think it's worked really well and since my little one had it, his breathing has improved a lot."* Participant 14, St Helens resident

Parents frequently stated that children were using their inhalers less often and sleeping more comfortably, which they saw as early signs that the home environment had improved. For some families, this stability also translated into fewer medical appointments or emergencies.

Although these reports are self-described rather than clinically verified, the consistency of reporting across families suggests this may be a positive outcome of the programme. Parents felt that the combination of education, visible feedback from the monitor, and sustained support from programme staff, encouraged practical changes that reduced environmental triggers.

In several households, improvements extended beyond the target child to other family members with asthma, or general respiratory sensitivity (e.g., wheezing). Several

parents often spoke of the home feeling “fresher” or “lighter,” linking this to better ventilation and reduced use of sprays and candles.

> *“I have breathing problems myself; it’s even helped me with the air. I’m not needing to take my own pump [inhaler] as much.”* Participant 14, St Helens resident

Another resident said,

> *“Yes, definitely, definitely, because my other daughter as well, she suffers with emphysema and everything, so it’s helped us think about her as well, that she’s getting the quality in her room.”* Participant 15, Warrington resident

In addition, the qualitative data showed a perceived positive direction for several families regarding their physical health in that children were using their reliever inhalers less often.

> *“The brown [inhaler] he has to use every day. He hardly uses the blue inhaler, which is great […] he hasn’t used it for a couple of weeks at the moment, so yes, it’s really good.”* Participant 13, St Helens resident

> *“He’s reduced the daily one [inhaler] in the summer we’ve stopped using it, just used the blue sporadically.”* Participant 15, Warrington resident

Several families also described fewer medical appointments or emergencies which supports the reduction showed in the statistical analysis:

> *“He’s not been in hospital since January [six months prior], which is a good sign.”* Participant 20, St Helens resident

Others described similar reductions in hospital or GP visits:

> *“He has a cough every now and then, but generally he’s quite all right. [The] last twelve months he’s had no doctor visits or hospital visits, so it’s been quite under control”* Participant 13, St Helens resident

These qualitative findings suggest that the programme’s impact was not limited to individual outcomes but may have influenced wider household wellbeing.

Physical improvements were also supported by the programme’s ability to address environmental risks beyond families’ immediate control. In a small number of cases, programme staff intervened directly with landlords or housing providers to expedite urgent repairs for damp or mould.

> *"The programme actually got in contact with my housing as well, spoke to them and said about getting work done with the mould and they've come out. They've done that. So, it's been amazing how you can actually help with the housing situation as well, getting work done that needs to be done."* Participant 14, St Helens resident

One resident described how the team's advocacy had fast-tracked home repairs related to black mould:

> *"I called up my housing and they said I'd have to go on a two-month waiting list… then when I had my update, I said to the person [Air Quality Trainer] on the phone, is there any way you could help me maybe try and jump up the list and literally within like three days, I got a call from the housing saying they were going to send someone out in the next 48 hours, and they did."* Participant 14, St Helens resident

These examples highlight how the programme's remit sometimes extended beyond behaviour change to tangible environmental improvement. By liaising with housing services and empowering families to use IAQ data as evidence, the programme helped reduce risks (e.g., mould) that contributed directly to respiratory ill health. Parents felt that this kind of advocacy was rare and transformative, bridging the gap between health advice and the practical realities of poor-quality housing.

Taken together, these accounts suggest that for some households, the programme modestly contributed to health benefits and improved environmental conditions. Families described fewer symptoms, less reliance on medication, and reduced acute care, as well as visible improvements in the home itself. While these changes cannot be attributed solely to the programme (due to the strength of the evidence), they demonstrate a plausible link between increased awareness, modified household behaviours, and improved stability in children's respiratory health.

Psychological Health Benefits

Alongside physical improvements, many parents described important emotional and psychological benefits from taking part in the programme. Across interviews, households emphasised that having clear, personalised feedback on their home environment helped them feel less anxious about their child's asthma. Parents who had previously felt uncertain or powerless described feeling reassured that their actions had the potential to make a tangible difference. For a few households, the programme replaced worry and guesswork with understanding and control. One parent explained:

> *"It did help me, as a mum, to see where I am, to not go mad in the house, like, getting everything out, and be pointless, that thing, because you don't know if you're doing something good, you don't know if you're right or wrong, so yes, I would recommend it."* Participant 3, St Helens resident

Another parent reflected,

> *"It's definitely made me much more proactive and engaged with like monitoring what's going on… So that's been kind of reassuring. So, I think it's definitely made me much more engaged with air quality in a totally different way."* Participant 16, Warrington resident

Many families described how the air quality monitoring itself acted as a source of reassurance. Seeing the readings in real time (and then later comparing them in the reports), gave parents a sense of confirmation that they were making the right behavioural changes. Several parents said it helped reduce the feeling of helplessness that often accompanies caring for a child with asthma. The ability to see cause and effect of their behavioural changes (e.g., readings improving after opening windows or reducing chemical sprays), turned the invisible risks of poor air quality into something manageable. This growing sense of control was reinforced by supportive contact from programme staff.

In addition, some parents valued the opportunity to talk through their data with someone knowledgeable, describing these conversations as "calming" and "reassuring." Those who had felt anxious or sceptical at the start said that staff communication helped them build confidence over time. One participant described how this relational approach made the programme feel different from other services:

> *"I had a phone call appointment in June, and I was asked, how am I doing, how is [child] doing, how is everything going, like, proper, had a conversation with somebody that had the time to listen"* Participant 3, St Helens resident

Several parents also noted that the programme made them feel more competent in managing their child's asthma (day to day). The combination of clear feedback, regular guidance, and visible results increased confidence that they could make informed decisions. For many households, this was not about eliminating anxiety entirely but about transforming it into something actionable and structured.

> *"It definitely has had a positive impact on all of us and helped us feel more confident that things that we're doing are working. So, I just really appreciate that we had the opportunity to do it, really."* Participant 16, Warrington resident

Together, these qualitative accounts highlight how psychological gains may have been an important factor of the programme's impact. Parents moved from uncertainty to informed participation, describing a shift from feeling reactive to feeling capable of longer-term symptom management. While physical outcomes varied, the sense of agency and reassurance from the programme appeared consistent across families, suggesting a greater sense of emotional competence to manage respiratory concerns.

Mixed or No Observable Health Changes

A smaller number of families reported limited or uncertain changes in their child's health following participation in the programme. Parents recognised that asthma symptoms fluctuate due to factors such as age, weather, exposure at school. They also suggested that the home environment had little influence on respiratory wellbeing.

> *"He only gets really bad asthma in the winter, and I think that tends to be more to do with the climate and not your house, do you know what I mean. If we probably didn't do what we did he could be a lot worse maybe, but I wouldn't know."* Participant 8, St Helens resident.

Parents also acknowledged the difficulty of isolating the impact of the programme from other contributing factors, describing a thoughtful realism rather than disappointment.

> *"There's only a very minimal impact on him. I know which you couldn't really see. So I've not noticed any difference at all but clearly it will have a difference even if it's only a slight one. So, and that's what you have to think isn't it? You know, sometimes you don't see a massive change to things. It doesn't mean it's not beneficial."* Participant 12, St Helens resident

Another parent similarly stated:

> *"He's definitely getting better, but whether it's age related or air related, it's hard to know."* Participant 15, Warrington resident

Taken together, these reflections suggest that three families did not observe any improvements in respiratory health or did not feel confident in the impact of the programme. For these households, the programme was understood less as a treatment producing immediate results and more as an ongoing effort to reduce potential triggers. The absence of clear improvement did not necessarily undermine engagement, but it highlighted the complex, multifactorial nature of respiratory health management.

Changes in Awareness, Behaviour and Attitudes

Changes in Awareness of Indoor Air Quality

Awareness and learning represented the starting point for participant engagement with the programme. Across all twenty interviews, parents and carers described entering the programme with little to no prior understanding of indoor air pollution. They often viewed health and the home as separate domains, seeing asthma as a purely medical issue to be managed through inhalers and GP visits. Even parents whose children had lived with asthma for years had never been advised by healthcare professionals to consider environmental triggers inside the home. The programme disrupted this perception by reframing the home as part of the health environment, prompting a process of reflection, learning, and behavioural change. Families often expressed surprise, and even mild frustration, that such practical, health-relevant knowledge had not been offered sooner. The programme therefore acted not only as an intervention but as a corrective to an existing information void in routine clinical care.

> *"No, never, I'd never heard of it [indoor air quality] before until that day."* Participant 14, St Helens resident

Learning occurred gradually through a combination of education (at monitor installation), written guidance, feedback calls, and the presence of the monitor itself. The monitoring device translated an abstract concept (indoor air quality) into visible data, showing families, how everyday actions affected the air in their homes (solidifying the learning process). Parents described this process as eye-opening and empowering, as it allowed them to see cause and effect rather than just being told about it.

> *"Yeah, I think because you watch it and you kind of like know if it's going up, you kind of, like, do things to make it go back down."* Participant 2, St Helens resident

Through these interactions, families began to link air quality directly to their children's health, reframing the home from a passive space to an active site of health management. The monitor's readings transformed invisible risks into something tangible, allowing participants to make sense of the relationship between cooking, cleaning, ventilation, and respiratory wellbeing.

> *"It's just become part of the routine now, because obviously I've had it for twelve months, so it's just a little thing when I'm pottering about."* Participant 13, St Helens resident

As a result, the programme filled a crucial educational gap and reshaped how families thought about health and environment, fostering a sustained awareness that extended beyond the duration of the programme.

Behavioural Changes

Behavioural change was a key outcome of the programme, with qualitative interview data suggesting that households had made key changes to their home routines. Families described moving from awareness to sustained action, integrating new habits into daily life. These behaviours, initially prompted by the monitor and then reinforced through feedback calls, quickly became "second nature" and extended to other family members. This created a shared sense of responsibility for maintaining healthy air quality at home.

Once families understood the relationship between everyday activities and their monitor readings, they began to adapt their behaviour accordingly. Actions such as opening windows, using extractor fans (while cooking), reducing candle use, and avoiding strong cleaning products became automatic over time. Many participants said they no longer needed the monitor to prompt them because these behaviours had become habitual.

> *"We open his [child's] window a lot more than we ever did before. Because he doesn't like it and you know, throughout the day and he'll go and shut it and I'm like open that window."* Participant 16, Warrington resident

Behaviour change extended beyond individual parents to include children and partners. Families described how shared observation of the monitor encouraged everyone to contribute to maintaining better air quality, turning it into a collective household effort rather than a single person's responsibility.

> *"My husband's been interested in it as well. He was here when [anonymised] went through it and he interacts a bit as well, to keep an eye on things."* Participant 16, Warrington resident

Families described how having a visual tool (i.e., air quality monitor) helped them translate their learning into consistent, practical habits that became embedded in daily routines. Behaviour change expanded across whole households, with parents, children, and partners collectively maintaining healthier indoor environments beyond the duration of the programme.

What Prompted Behaviour Change?

In the section below we summarise our findings with regard to changes households made in their behaviours potentially influencing air quality.

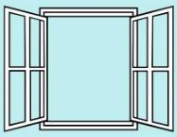
Title	Learning	Changes Made
Ventilation and Airflow 	Families learned that ventilation supports respiratory health rather than undermining comfort.	Families began keeping windows slightly open year-round and using vents to maintain airflow.
Cooking and Extractor Use 	Participants discovered that cooking raises pollution and that extractors can reduce exposure.	Families routinely used extractor fans and opened windows during cooking to improve air quality.
Candles, Plug-ins, and Incense 	Families were surprised to learn that scented products worsen air quality and asthma symptoms.	Households reduced or stopped using candles, plug-ins, and incense to limit pollutants.
Cleaning Sprays and Chemicals 	Families realised that strong cleaning products can trigger asthma and poor air quality.	Families switched to milder cleaning products and ensured rooms were ventilated when cleaning.
Damp, Humidity, and Dehumidifiers 	Families connected humidity and damp with asthma symptoms and learned how to manage moisture.	Families used dehumidifiers, opened windows more often, and sought repairs to reduce damp.
Outdoor Context and External Pollution 	Families understood that external pollution can affect indoor air, requiring context-aware ventilation.	Families opened windows strategically depending on outdoor air quality and location.

Figure 44. Learning that prompted household behaviour change

Ventilation and Airflow

Participants often assumed that closing windows protected their children from cold air or outdoor pollution. The programme reframed ventilation as a fundamental health behaviour, helping families see airflow as directly linked to asthma management rather than comfort or temperature. Once households watched the data on their monitors improve when windows were opened, they began to adjust their daily routines, keeping windows open or using trickle vents during colder months:

> *"Yeah, so we always have windows open, and we've got new windows with vents on at the top so they're always open all year round so there's always like fresh air circulating."* Participant 7, St Helens resident

> *"Opening the windows more, especially because ours is open plan, so if you're doing any cooking and stuff, getting the windows open. Yes."* Participant 13, St Helens resident

This shift was described by some households as counterintuitive but transformative. Families explained that before the programme, warmth and comfort had often taken priority, particularly in older or poorly insulated homes. After learning that stale or humid air could trigger asthma, they redefined good ventilation as a protective act rather than a source of discomfort. For some, this learning also extended to teaching children to manage windows themselves, creating shared family responsibility. Over time, these practices became part of normal household routines; an everyday behaviour sustained by visible, data-driven reinforcement.

Cooking and Extractor Use

Cooking emissions were one of the most surprising lessons for more than half of households. Participants described being unaware that everyday meals (especially frying or using toasters) could cause air quality readings to spike (or reduce air quality). The programme reframed cooking from a routine household activity into a key moment of environmental control, encouraging families to use extractor fans, open doors or windows, and adjust habits (e.g., frying less frequently or keeping children out of the kitchen while cooking).

> *"We don't fry things often and you know very rarely use a toaster and things. […] I shut the door between the kitchen and the living room. Open windows, open the doors."* Participant 12, St Helens resident

> *"So, the vent thing, I think I've realised how important that is, and also even things that can affect it like just cooking, simply cooking*

and we were spending a lot of time basically in our, his playroom is essentially next to the kitchen, so maybe just shutting doors." Participant 19, Warrington resident

Through the monitor's visible feedback, families could directly link their cooking practices to indoor air quality, creating key moments of real-time learning. Many described noticing spikes in readings while preparing food and then seeing the numbers fall again once ventilation was improved (e.g., opened windows or extractor fan). This immediate feedback reinforced consistent extractor and window use, helping families see that small practical actions could make a measurable difference. Over time, these habits became routine as participants reported automatically turning on fans or opening vents whenever they cooked, embedding healthier practices into daily life.

Candles, Plug-ins, and Incense

Another learning point for many families came from discovering that scented products such as candles, plug-in air fresheners, and incense, could substantially reduce indoor air quality. Parents often described this revelation with surprise or disbelief, explaining that they had long associated pleasant scents with cleanliness, relaxation, and comfort.

"I mean, before starting this programme, I didn't know that candles were not good. I light so many candles, and I was like, oh, maybe I should not light as many candles." Participant 1, St Helens resident

The idea that these using candles might worsen asthma symptoms felt surprising and counterintuitive:

"So, I've tried to dial down on using candles because I'm one of those ones, I absolutely love scent, I love candles, incense around my house to make it smell nice. So I've had to stop using all those and it's one of those, ah, it's annoying because I want to use it." Participant 14, St Helens resident

"I did used to use candles quite a lot, you know, just like scented candles. I had no thought that could impact his asthma, so that was a big change that I made." Participant 16, Warrington resident

For more than half of households interviewed, this was a profound shift in mindset. Scented products had often been part of routines associated with care and domestic

pride, so removing them required not only practical change but also emotional adjustment.

> *"Yes, the plug-ins, they're meant to be really bad as well, so that's something I've definitely clocked onto since."* Participant 19, Warrington resident

Some parents also shared these findings with friends and relatives, indicating that learning extended beyond the household. This often-prompting others to take an interest in indoor air quality:

> *"My daughter's best friend at school, she lives with her nan, and her granddaughter's, like, bad with her asthma as well. And she was like, 'how did you get that?' And I was like, through the asthma nurse. So, she got in touch herself."* Participant 1, St Helens resident

Others described similar ripple effects within their families, where discussions about the programme encouraged wider awareness and curiosity about air quality. As one parent recalled:

> *"I spoke to my mum about it, because my sister, she's 23 now, and I think she outgrew her asthma. She doesn't require inhalers anymore. When I brought it up to my mum, you know, she was trying to look into it for herself but at this point, [Anonymised], my sister, she's too old now, she's past that point but she said if my sister was a lot younger, and this was an opportunity, she would have 110% gone with it."* Participant 11, St Helens resident

These examples suggest that the discoveries families made, particularly around scented products and hidden household triggers, became memorable and widely discussed. The sharing of information with peers and relatives indicates that the programme's influence reached beyond direct participants, helping to raise broader community awareness about the role of everyday domestic environments in managing respiratory health.

Cleaning Sprays and Chemicals

Families were particularly struck by the idea that cleaning products could actually worsen asthma and air quality. Many participants admitted they had never considered the potential risks of sprays, bleach, or perfumed cleaners before joining the programme. Learning about this link was both surprising and transformative, prompting a reassessment of what "clean" meant within the home.

> *"I've completely cut out bleach because I noticed that was very strong and it was affecting the machine and my little one's breathing at the time. So, I've completely cut that down and tried not to use so much."* Participant 14, St Helens resident

> *"Like he said, obviously, you're cleaning products and stuff can give off things, which I understand they give off a smell anyway, but I didn't realise the extent of what they can do. I've learnt that and stuff. But I said to him, like, obviously, when they go to school, I'll clean."* Participant 1, St Helens resident

For some parents, this learning challenged deep-seated habits and cultural ideas about cleanliness. Cleaning had often been framed as an expression of care, particularly for mothers of children with asthma, so the notion that "cleaning too much" or using strong products might worsen their child's health required a conscious shift in mindset. Participants described strategies such as cleaning only when children were at school, switching to milder or unscented products, and ensuring windows were open during and after cleaning.

These accounts highlight how knowledge translated directly into daily routines. Rather than abstract advice, the information was immediately actionable: families could see air quality readings improve after reducing bleach or increasing ventilation, providing powerful, visual reinforcement that encouraged change.

Damp, Humidity and Dehumidifiers

Damp and humidity emerged as a common theme across interviews, particularly among families living in older or rented properties. Many participants described learning, often for the first time, that humidity spikes could directly affect asthma symptoms and overall air quality. The programme helped families recognise these patterns by showing them visible data from the monitor, how moisture levels rose after activities such as drying clothes indoors or showering, and how this could worsen breathing conditions.

> *"Using a dehumidifier, you can then see what impact that is having on the air quality. So mainly I've kept it in his room, because obviously that's the area, for a couple of reasons really, that was the area that I was most worried about."* Participant 16, Warrington resident

> *"Where it's also helped as well, because of where I live, it's quite bad for like obviously like mould, it's actually helped with that as well, like drying it down."* Participant 14, St Helens resident

Families described taking practical actions to reduce humidity, from keeping internal doors open after showers to purchasing dehumidifiers and contacting landlords for repairs.

> *"Yes, I've been opening the windows a lot and we've bought a dehumidifier as well."* Participant 13, St Helens resident

Several parents said the data empowered them to advocate for housing improvements, providing evidence that damp and poor ventilation were affecting their child's health. For some, this learning was reinforced by visible reductions in mould and a fresher smell at home, which gave them reassurance that their efforts were working.

Importantly, this area of learning often intersected with issues of housing quality and social inequality. Participants renting older or poorly ventilated homes described persistent structural damp beyond their control, but the programme helped them take smaller independent steps to mitigate the problem. Even in these cases, families expressed that understanding how humidity affected asthma gave them a sense of agency and confidence in tackling environmental triggers.

Outdoor Context and External Pollution

A further focus of learning involved families realising that ventilation was not always straightforward. While most participants learned to keep windows open to improve indoor air quality, some also discovered through the monitor's data and programme feedback, that outdoor pollution could at times make things worse. This understanding reflected an evolution in learning: families moved beyond simple "open or close the window" advice toward more contextual, situational awareness.

> *"But the one thing that I didn't think about was the quality of our outside as well. So sometimes opening your windows is a negative thing. So, it's dependent, obviously where you where your home is, isn't it really and where you're opening your windows."* Participant 12, St Helens resident

> *"Like some of the other spikes that were on the monitor were national spikes, but where our ratings were red, there'd been a corresponding national or local or regional, I don't know how they look at it, but she said oh actually, there was a high day, there was a lot going on that day and it was higher in that area. So that's been kind of reassuring. So I think it's definitely made me much more engaged with air quality in a different way."* Participant 16, Warrington resident

For several families, this learning came as a surprise. They had initially understood ventilation as universally positive but came to appreciate that context mattered. Some participants began checking local air quality reports or adjusting when and how long windows were opened depending on outdoor conditions. Others said the programme made them more aware of environmental issues beyond their own homes, prompting interest in national air quality alerts and conversations about pollution in their local area.

This progression marked a key shift in understanding within the set of programme respondents. Families demonstrated the ability to interpret environmental information dynamically, recognising that air quality fluctuates and that "healthy behaviour" depends on timing, location, and weather. Rather than a static rule, ventilation became an informed, flexible decision, showing how the programme fostered deep environmental literacy and empowered participants to adapt their actions to changing conditions.

Attitudinal Changes

Alongside clear behavioural shifts, families also described a profound change in how they thought about health and the home environment. At the start of the programme, most parents viewed asthma management as purely medical, something managed through inhalers, prescriptions, and GP appointments. By the end, many had reframed their understanding to include the home as an active part of their child's health environment. This attitudinal shift, from passive management to proactive care, was one of the most meaningful outcomes of the programme.

Before participating, some parents described feeling powerless to prevent flare-ups or reliant on medication to manage symptoms. The programme introduced a sense of agency, showing families that small environmental changes could make a tangible difference. This practical empowerment replaced anxiety with reassurance and motivated families to stay engaged.

> *"So I think it's definitely made me much more engaged with air quality in a totally different way."* Participant 16, Warrington resident

For many, the most striking attitudinal change was learning to view their home as integral to their child's wellbeing. Parents began to interpret their environment through a health lens, seeing everyday actions like cleaning, cooking, and ventilation as direct contributors to respiratory health. This shift transformed domestic routines into purposeful, health-promoting behaviours.

Families described increased confidence in managing both environmental and health-related challenges. Many spoke about feeling equipped to maintain good air quality independently, trusting their own judgment rather than relying solely on professionals.

The visible feedback from the monitor helped to reinforce motivation, translating invisible risks into manageable, measurable goals.

> *"Yeah, I think because you watch it and you kind of like know if it's going up, you kind of, like, do things to make it go back down."* Participant 2, St Helens resident

Parents noted that the programme encouraged a more collective sense of responsibility for health within the household. Children and partners became more attentive to air quality, reinforcing positive habits and contributing to a family-wide attitude shift toward shared care and prevention.

> *"Yeah. 'Look mum, the numbers are big.' […] She opens the bedroom window and all sorts."* Participant 9, St Helens resident

The programme encouraged an attitudinal transformation among participating families. Parents came to view air quality as central to health, not peripheral, and felt empowered to act rather than react. This shift in mindset, towards ownership, control, and shared responsibility, was key to sustaining the behavioural changes and health improvements achieved through the programme.

Summary of interview findings

Interviews with participating households suggest that the Healthy Air for Healthy Lungs Programme was generally well received and helped increase awareness, understanding, and confidence to improve indoor air quality. Many families described gaining new insight into how everyday household practices may influence air quality, supported by personalised feedback from air quality monitoring and regular contact with programme staff.

More than half of families interviewed reported perceived improvements in respiratory symptoms, such as reduced inhaler use or fewer healthcare visits; however, these outcomes were self-reported and not observed universally. Some parents reported little or no change and highlighted the difficulty of attributing health improvements solely to the programme, given the influence of other factors (e.g., seasonal weather).

Programme Implementation Insights

The following section reports on the insights that may help shape the future implementation of a Healthy Air for Healthy Lungs Programme. Drawing on qualitative interview data with staff, it highlights the ways in which delivery teams and partners modified recruitment, engagement, and operational processes to ensure the intervention remained feasible and meaningful within local government and health service contexts. The section also captures perceptions from programme staff and households on the key barriers and enablers to successful implementation.

Barriers and Enablers to Successful Implementation

Implementation Challenges

Although stakeholders generally described the Healthy Air for Healthy Lungs Programme as well-received, most recognised that delivery was shaped by a number of important implementation challenges. These were most evident in the early stages, when data governance, eligibility criteria, and resource constraints slowed progress and placed additional strain on delivery teams. Over time, infrastructure, communication, and contextual disparities between the two boroughs also emerged as a challenge.

Figure 55. Key Barriers to Implementation

1. Data Access and Governance Barriers

The most frequently cited challenge concerned access to NHS data and information-governance restrictions, which prevented the team from using GP systems (EMIS and CIPHA) to identify eligible families. This issue had been foreseen by some stakeholders but not fully resolved before launch, leading to delays, uncertainty, and frustration among partners.

> *"We were trying to get access to certain data that was not something that the local authority had access to. So, we were trying to see how we can hire a part-time person within GP practices to pull the data, but then there was a lot of barriers on that as well. So, a lot of those early stages I think we didn't do as much sufficient on preventing. There was a lot of barriers that I think we faced that caused us to move forward."* Stakeholder 1, Project Officer, Warrington

The lack of timely data access delayed recruitment and highlighted mismatched expectations between local authorities and NHS partners about what was feasible within short-term timescale. This reinforced a lesson later echoed by several participants: that research-style programmes in health settings need protocol development time and data-sharing agreements in place before implementation.

2. Restrictive Eligibility Criteria

Another key barrier related to the participant eligibility criteria of the programme. Several stakeholders felt that the original inclusion criteria (children aged 2-10 with a salbutamol prescription and living in an air-quality-management area) was too narrow and unrealistic, given local demographics and housing distribution. The combination of age, condition, and geographic boundaries drastically limited the available pool of families and contributed to early recruitment bottlenecks.

> *"One of the main barriers was actually the criteria at the beginning of the programme. And so obviously the eligibility was children 2 to 10 and they had to have the salbutamol inhalers, but they also had to live in an air quality management area…I think that was just too narrow for the programmes and I think that's had a huge impact on the recruitment, because we just didn't have a child who was between that age group who had the salbutamol inhalers and lived in an air quality management."* Stakeholder 9, Public Health Officer, Warrington

Others noted that these criteria were set externally by DEFRA, leaving little room for local tailoring. While this constraint limited early reach, it also prompted constructive adaptation later as eligibility was broadened to include families across both boroughs.

3. Capacity, Staffing, and Continuity Issues

Another key barrier to implementation was issues relating to programme staffing. Several stakeholders described turnover in key roles, particularly within programme management, which disrupted continuity and communication between areas. One early-stage lead stated:

> *"Continuity of programme management, the investment in programme management, is really key to any initiative but I think it was really key for this one."* Stakeholder 2, Public Health Officer, Warrington

In practice, changes in leadership and temporary contracts slowed progress and made it difficult to maintain consistent oversight. As one manager explained:

> *"I had a one-year contract for a two-year programme, so it meant that it was picked up by someone else after I left […] it was frustrating to have to leave before the end of the programme."* Stakeholder 5, Former Project Team Member, St Helens

These personnel changes sometimes meant that newer staff inherited incomplete handovers or were unfamiliar with earlier decisions, creating uncertainty around structures and responsibilities.

> *"The public health team within Warrington was going through a bit of a transition […] the people who were originally part of the negotiations on the arrangement of the bid process had left, so the people who came in were not knowing as much about the bid as perhaps they would have been had we all been involved from the start."* Stakeholder 5, Former Project Team Member, St Helens

Several stakeholders also described limited capacity within local teams, which compounded the impact of turnover and added pressure to already stretched staff. One consultant highlighted:

> *"they're relying on us as a team to be doing more and more and we don't have the capacity. We don't have the funding because the funding sat in St Helens,"* adding that *"I've got a member of staff who's on maternity, and I've got another member of staff that's doing other stuff. But yeah, we're having to drop everything. And actually, you know, I'm quite a senior post and I'm doing programme work."* Stakeholder 11, Public Health Officer, Warrington

Together, these accounts illustrate how turnover, capacity gaps, and unclear handovers could impact programme coordination and pace. The findings highlight the importance of stable leadership, structured documentation, and clearly defined roles to sustain delivery across multi-agency programmes.

4. Operational and Logistical Difficulties

During the programme, the delivery team encountered operational complexities such as coordinating home visits across boroughs, managing equipment, and maintaining consistent reporting systems. Staff from the wellbeing service described how the administrative burden of tracking participants, collecting data, and ensuring accurate records, reduced their capacity to deliver impact.

> *"It was full on for the onboarding part at the front part of the programme. So very much you know sort of managing that, that referral and all the incoming traffic really booking all the appointments for the team to go out."* Stakeholder 4, Health Trainer

While these systems eventually became a strength, they required significant time and troubleshooting to establish. As one delivery lead explained:

> *"We had to come up with a process that suited everyone […] I knew a lot of the barriers, so I knew how to approach people, what questions to ask and I just made sure that I facilitated it and made sure that everyone was aware of their tasks and what they needed to do so that we could get the best outcomes."* Stakeholder 10, Delivery Lead

The scale of the monitoring process, combined with staff turnover and technical challenges, sometimes meant the team were developing systems and solutions in real time as delivery progressed.

5. Communication and Branding

A cross-cutting barrier that was described in multiple interviews related to communication and identity. Stakeholders from Warrington felt that programme materials and communications were branded around St Helens, creating confusion for Warrington residents which dampened local ownership.

> *"I think a lot of the comms that were produced were very much St Helen's focused. And kind of not fit for purpose for Warrington a little bit, I think sometimes the way that they designed some of the comms around the programme, it didn't include Warrington Borough Council logo. So, I don't know whether kind of Warrington residents thought, oh, this isn't a programme for me because it didn't look like it was."* Stakeholder 9, Public Health Officer, Warrington

> *"It had to be led by St Helen's because they put the bid in on our behalf, but everything sort of seemed to be branded as St Helen's. It wasn't that they deliberately did that, but the support came from St Helen's, you know, if you went to the website about the programme, it was St Helen's*

branded, I think that possibly confused a few people in Warrington." Stakeholder 2, Public Health Officer, Warrington

This lack of visible Warrington representation was not viewed as a deliberate oversight but as a by-product of resource imbalance and lead-partner dynamics. However, it reinforced perceptions of the programme as "belonging" to one borough, which stakeholders believed reduced initial buy-in among both professionals and households.

6. Differences in Local Settings

Stakeholders repeatedly contrasted the two boroughs' infrastructure disparities as ongoing barriers to implementation. St Helens benefited from pre-existing air-quality and respiratory initiatives (such as the Taurus programme) that had already raised local awareness and trust, whereas Warrington lacked an equivalent foundation.

> *"Obviously the uptake in St Helens was much faster and greater compared to Warrington and I think you can't know for sure, but I think people, it's generally considered it's likely because of the Taurus programmes being in St Helens […] that's why it's believed that it was a bigger uptake in St Helens."* Stakeholder 6, Health Officer, St Helens

> *"There's probably better links with partners than in the Warrington ones and that's probably the reason for the slower uptake in the Warrington area. […] So because that work had already gone on and trying to identify households [in St Helens] with respiratory problems, I think there was just that little bit further on than the Warrington area. So those links were already in place."* Stakeholder 3, Public Welfare Officer, St Helens

This disparity in local readiness sometimes created a sense of imbalance and frustration among Warrington partners, who felt the lack of a dedicated local operational team limited reach and responsiveness.

> *"I think we could have had a dedicated Warrington operational team to drive that recruitment because they would have had the knowledge of Warrington, they would know communities in Warrington possibly a little bit more than the St Helens wellbeing team."* Stakeholder 9, Public Health Officer, Warrington

7. Delivering Education and Training for Families

Although education was a central feature of the intervention, stakeholders described several barriers that affected how consistently it could be delivered across participating households. Programme staff often emphasised that while the aim was to provide clear, accessible information on indoor air quality and healthy home behaviours, engagement and communication barriers sometimes limited the impact of this education.

A key challenge related to variation in family engagement and willingness to participate. Stakeholders noted that households who self-referred to the programme were typically more motivated and receptive to guidance, whereas those referred by external professionals could be more cautious or uncertain about the programmes purpose. As one programme officer explained:

> *"Whenever you get what we call self-referrals. So that might be somebody that's willing, they've referred themselves because they want to make those lifestyle changes [...] Sometimes when we had referrals from the respiratory team. So, like when the respiratory nurse had had sent his names and you know names of clients of clients that had consented to be contacted but didn't know that much about it. You know, there were a few on that that sort of said I don't really like the sound of it."* Stakeholder 4, Health Trainer

In some cases, this hesitation was linked to concerns about the monitoring technology. Families expressed uncertainty about how the devices worked and whether they might intrude on privacy, which created additional barriers to engagement:

> *"There were a few [potential participants] on that that sort of said I don't really like the sound of it. I don't feel as though, you know, there might have been that, you know, speculation about was they being monitored? Was it a bit Big Brother?"* Stakeholder 5, Former Project Team Member, St Helens

Alongside these challenges, staff also highlighted difficulties maintaining contact with some families, which limited opportunities to reinforce key educational messages over time. Competing household demands and communication barriers occasionally led to gaps between follow up:

> *"We can only try and call people so many times. You know, so, you know, there may be the occasion where we have tried to call people two or three times. We've not been able to, to reach them and then we've got to put it to the next, you know, sort of three month or six-month stage because we you know we can't just keep-"* Stakeholder 4, Health Trainer

These staff reflections were mirrored in the feedback from families themselves, who highlighted a series of practical barriers and small adjustments that could further strengthen educational engagement. While most parents valued the opportunity to discuss their data during calls, some explained that the written reports themselves could be difficult to interpret without additional explanation. For a few, the graphs and colour coding were visually striking but not immediately meaningful, particularly for those without a technical background. Some described feeling unsure what specific readings referred

to, or how to translate those indicators into action, suggesting that simplifying the presentation could make the information more accessible and useful.

> *"The report is very confusing, doesn't make much sense, so someone did have to break it down for me, so that could probably be a bit simpler. I can't make head nor tail of it. […] It's just a whole lot of graphs and green and reds and then it's like well, what? I don't know what half of the things were because obviously they were saying CO2 or such and such a thing, and I'm like, I don't know what half of that is. So yes, you probably need to simplify on that."* Participant 20, St Helens resident

Parents also raised the importance of communication logistics, noting that while staff were always friendly and supportive, the timing of follow-up calls could sometimes make it difficult to connect. Several families suggested providing set time windows for feedback appointments rather than ad-hoc calls, explaining that predictable slots would make it easier to plan around work, school runs, and other responsibilities. Others proposed flexible reminders or text prompts to reduce the likelihood of missed calls, emphasising that these barriers were practical rather than attitudinal.

> *"You get a text message, and then at any point in that day I think, you just get a phone call, which I do think they could improve on. You know, people like me, who we're in and out, and we're doing things, or I'm to and frow with the school, because I have a lot of meetings for my daughter as well, because of her disabilities. So, I always have something going on. So really, a time scale, like an hour, or whatever, could really help people as busy as what I am."* Participant 11, St Helens resident

Together, these reflections show that the main barriers to engagement were often practical and easily remediable. Simplifying report design, clarifying data language, and offering clearer scheduling or reminders would, in parents' view, make participation even smoother and reinforce the educational value that they already found beneficial.

Summary

In summary, the programme faced complex challenges from data governance and restrictive eligibility, to staffing, communication, and contextual inequities. Despite these barriers, stakeholders generally framed challenges as opportunities for learning and adaptation, highlighting how the programme's iterative nature allowed teams to troubleshoot and refine delivery. The experience highlighted the importance of clear governance structures, locally owned communication, sustained programme management capacity, and realistic recruitment strategies when replicating the model elsewhere.

Enablers of Implementation

While stakeholders highlighted some operational and structural challenges, both staff and families described a wide range of factors that enabled successful delivery and meaningful engagement throughout the programme. These enablers included committed and motivated delivery teams, strong leadership, collaborative cross-sector partnerships, and effective administrative systems that maintained consistency across two boroughs. Equally important were the qualities that families emphasised, including approachable staff, clear communication, flexible feedback, and low-burden participation, which together encouraged trust and engagement.

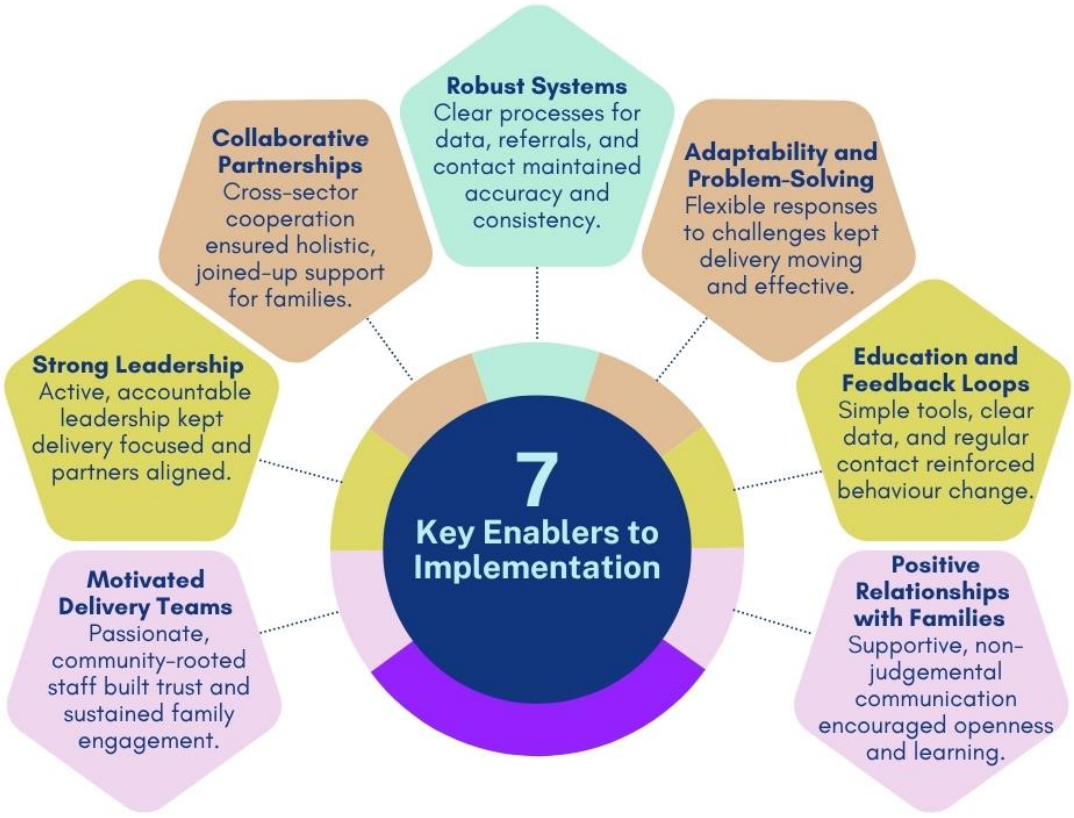


Figure 66. Key enablers to implementation

1. Motivated Delivery Teams

Across interviews, stakeholders consistently identified passion and enthusiasm as the single most important driver of the programme's success. The programme staff's (particularly City Health) passion for the project was attributed with building trust, ensuring consistent communication, and compensating for resource and governance barriers.

> *"I guess they knew that they had the capacity to help, so they've had the time to really put a lot of energy into it and also, they've been really positive, really keen, they think the programme's great. So, it's such a positive attitude which I think really helps."* Stakeholder 6, Health Officer, St Helens

> *"I think getting the right people involved in the programme. The programme leader is very passionate and really into it and he bumps that enthusiasm down he's really supportive, so having that right lead in play. Someone that you can talk to and run things by and things like that. Very hands on."* Stakeholder 4, Health Trainer

Delivery staff also emphasised how their familiarity with local communities and prior experience in social-prescribing, and health-promotion roles strengthened their ability to engage with families. This embedded local knowledge allowed for sensitive communication around household issues such as damp, smoking, and ventilation (topics that can easily be perceived as intrusive).

Families also described delivery staff as approachable, friendly, and never pushy. Households emphasised that conversations felt supportive and collaborative, which helped them feel comfortable discussing household habits that might otherwise feel sensitive or judged.

> *"They've been amazing. I had a phone call appointment in June, and I want to say, I've been asked, how am I doing, how is [child] doing, how is everything going, like, proper, had a conversation with somebody that had the time to listen."* Participant 3, St Helens resident

This was repeatedly credited with sustaining trust and openness throughout the programme, allowing families to engage honestly and act on advice.

2. Strong Leadership and Coordination

Clear leadership and structured governance were repeatedly identified as critical to the programme's stability and success. Strategic oversight from St Helens' Public Health and Environmental Health teams was viewed as essential in setting expectations, maintaining accountability, and ensuring that progress reports and funding requirements were consistently met.

> *"The Director of Public Health was probably key in making sure that it was as successful as it was. You know, really regular programme meetings and keeping people to account that things were being actioned and moved along nicely."* Stakeholder 3, Public Welfare Officer, St Helens

Regular, well-chaired meetings provided a mechanism for oversight and escalation, ensuring that decisions could be made quickly and operational barriers addressed.

> *"The meetings that we had with St Helen's Council, the biweekly meetings, that was really useful because we enabled people to provide updates about the programme, where it's up to, what was working well, what wasn't going so well, and it just provided an opportunity to escalate anything as well to the group and we would work through that."* Stakeholder 9, Public Health Officer, Warrington

This leadership structure was viewed as central to maintaining focus, direction, and momentum, providing the strategic coordination necessary to support effective partnership working across both boroughs.

3. Collaborative Partnerships and Shared Purpose

Effective partnership working was a central enabler of both recruitment and delivery. Stakeholders repeatedly emphasised that collaboration across local authorities, City Health Care, respiratory services, and housing teams allowed the programme to respond to families in a holistic, coordinated way.

> *"We've established a relationship right with the respiratory team. They were then included as part of the meetings with families, asking families, would there be helpful and willing to get referred into us and sending us the data through. We've then gone out and supported them when they've been doing events out in the community. So, it's a two-way process."* Stakeholder 4, Health Trainer

> *"We were working on a similar and other programmes with some respiratory nurses and COPD teams assisting households access to household support fund and they thought that that would be very beneficial to any recipients of the air quality monitoring."* Stakeholder 3, Public Welfare Officer, St Helens

Partnerships were also instrumental in building trust with families. Having multiple referral routes, from GP practices, schools, and community events, meant that families often heard about the programme from a familiar and credible source, reducing hesitation and increasing participation.

At a wider level, stakeholders described a strong sense of shared mission among partners. The perception that "everyone was pulling in the same direction" fostered openness, mutual learning, and resilience when challenges arose.

> *"I think it's been really good from the even before we bid for the programmes we were in calls. I definitely think there was more people involved at the start and people have dropped off. But then we've also had people join where appropriate and you know, we've had lots of Warrington involvement as well."* Stakeholder 6, Health Officer, St Helens

This ethos of joint working was regarded as one of the programme's most transferable lessons, particularly for other regions seeking to embed indoor air-quality interventions within wider health and housing systems.

4. Robust Infrastructure and Administrative Systems

Several stakeholder interviewees pointed to the creation of robust internal systems for managing referrals, tracking data, and recording family contact as another critical success factor. Though time-consuming to set up, these processes ensured accuracy, safeguarded data, and created efficiency once recruitment accelerated.

> *"We keep information on our system; it's a system that we use within the office. So that helps us to put the client on a database, tap information like the contact numbers, their e-mail address. It's all you know, very secure system and NHS style system. […] That then allows us to use that system for booking all the benchmark, you know, the three months, the six months and nine-month calls when we send the emails out to the client with the reports on, we'll log it all on that system. But we also have you know sort of spreadsheets as well. You know, we have the information backed up if you like. And sometimes it's easier to pull information from a database like a spreadsheet."* Stakeholder 4, Health Trainer

> *"The system and the way we've set it up works quite well and we set up our own inbox that we could receive all the referrals into. […] So, when we had referrals come in try and call them and then colour code and then I'd try and call them a second time and a colour code again, so we could keep a log of who we tried to call, who we had not try to call. So, I do think our systems have worked quite well actually."* Stakeholder 4, Health Trainer

The investment in structured data management also built confidence among partners that the programme was evidence-led, which in turn strengthened engagement from public health officials and commissioners.

5. Adaptability and Problem-Solving Mindset

Stakeholders also credited the programme's flexibility and problem-solving culture as a key enabler. The willingness to adapt, whether through revising eligibility, altering recruitment routes, or modifying incentives, was seen as crucial to sustaining delivery in complex environments.

> *"There was definitely an evolutionary aspect to it. It wasn't just set in stone, and they stuck to it. There were some changes made to improve the delivery."* Stakeholder 3, Public Welfare Officer, St Helens

Several stakeholders described how early challenges prompted practical changes to design and delivery. Eligibility criteria were widened to increase recruitment, with one participant noting that:

> *"We had to adapt and try other routes to the recruitment […] they were quite flexible and changed that, which I think did make a difference."* Stakeholder 9, Public Health Officer, Warrington

The introduction of air purifiers, adjustments to the incentive model, and tailored support for families with additional needs, were further examples of this responsive approach.

> *"We started implementing instead of the vouchers at the initial appointment, we were giving a £50 'Love to Shop' voucher, and I said why don't we wait for data after three months and then offer them either the voucher or an air purifier."* Stakeholder 10, Delivery Lead

This practical flexibility, combined with a clear structured service model, created a culture where fidelity and innovation could co-exist. This allowed staff to maintain consistency for families while learning and improving in real time.

6. Education and Behaviour Change Support

The educational component of the programme was widely regarded as one of its most effective and distinctive features. Both staff and households described how the structured model, combining clear information, visual feedback, and regular contact, helped participants understand indoor air quality and embed healthier, more sustainable home routines. What made this model successful was its blend of technical guidance and relational continuity: families could see, test, and discuss their progress over time, creating a learning process that felt collaborative rather than instructional (or dictatorial).

Families repeatedly described the monitoring kit as quick to install, and easy to live with. This low burden made participation straightforward and allowed them to focus on the educational aspects rather than the technology itself. Parents spoke of the monitor becoming a natural part of the home environment, something that quietly reinforced

learning without demanding constant attention. They explained that because it was easy to use, they were more open to engaging with feedback and sustaining new routines.

Stakeholders confirmed that this simplicity supported engagement, noting that families received both general advice at enrolment and increasingly tailored guidance as the monitoring data accumulated. This structured approach ensured that educational messages remained relevant and actionable throughout the intervention period.

> *"So there would be a clear schedule of giving people an initial sort of more generic advice. And then after having after a month or so of having readings from their air quality monitor then giving more personal advice on the individual measures of their indoor air quality components."* Stakeholder 8, Former Project Team Member, St Helens

The ability to show participants real-time graphs and personalised results made the educational element particularly powerful. Visual data gave families tangible feedback, transforming invisible concepts into something they could observe and respond to. Staff explained that the graphs were especially useful for reinforcing advice, as parents could see patterns over time and understand how everyday activities affected their air quality. This visual reinforcement motivated families to keep experimenting and learning.

> *"Because I started producing graphs, comparison graphs… as we started going through the winter months, you could see that the graphs were changing… that's why we brought in the purifiers as well to try and compensate."* Stakeholder 10, Delivery Lead

Regular follow-up appointments were equally important for maintaining engagement and supporting learning. The scheduled three-monthly visits/ follow ups created accountability while allowing staff to revisit advice, discuss progress, and celebrate improvements. For families, these points of contact provided reassurance that their efforts were being noticed and that changes were worthwhile.

> *"He'll first get a referral and then he'll call them… go to their house… he's always had the same sort of script and then he's stuck to doing the follow-ups at 3, 6, 9, 12 months."* Stakeholder 7, Project Lead, St Helens

While most participants felt that this pattern of contact worked well, some families suggested that more frequent feedback, particularly early in the programme, could enhance learning. Several parents felt that monthly check-ins during the first few months would help them connect their day-to-day actions with the monitor readings more clearly, while they were still learning how to interpret the data.

> *"I suppose in some ways I might have found it helpful to get the data more often, like monthly rather than quarterly, but I do recognise that's a big*

ask, but by the time you get three months passed, you're a bit disconnected." Participant 16, Warrington resident

In addition to timing, families suggested a few practical improvements to make feedback and communication more accessible. Several recommended being shown a mock or example report during installation, so that when the first real report arrived it would feel familiar rather than overwhelming. Others asked for alternative contact methods, such as text messages or email summaries, to help them stay engaged when busy or unable to take calls.

7. Positive Relationships with Families

Front-line staff emphasised that the success of the educational component ultimately depended on the relationships that delivery teams built with families. The consistency, technical knowledge, and personal approach of staff were repeatedly credited with sustaining engagement, particularly among families who were initially hesitant or overwhelmed. Parents often described staff as friendly, patient, and genuinely invested in helping them understand their data. From the staff perspective, this sustained contact was key to embedding new habits:

> *"It took literally in some cases up to nine months of continuous calls and awareness and education to get them their behaviours to start changing so that it's a way of life rather than just because of the programme."* Stakeholder 10, Delivery Lead

Families echoed this sense of care, describing the team as approachable, consistent, and supportive. The tone of communication was repeatedly highlighted as a strength: parents felt they could ask questions without judgment and receive clear, practical guidance in return. For many, the friendly and conversational approach was what kept them engaged and willing to continue learning.

> *"I feel like they're all very friendly, like no matter who you talk to they're all friendly. But they're also very informative. Like they always tell you what you need to know, anything that you can do to change. I don't feel like they're very pushy, they just give recommendations, rather like, you need to do this. So, I feel like that works really well."* Participant 10, St Helens resident

Parents often spoke with warmth and humour about their interactions with the team, noting that staff were both professional and personable.

> *"They're nice. I can't fault them."* Participant 1, St Helens resident

Together, these accounts demonstrate how the educational component evolved into an iterative, relationship-based process rather than a one-off information exercise. Families

learned to interpret feedback, adapt their behaviours, and trust their own judgment over time. This model, anchored in accessible technology, regular reinforcement, and human connection, enabled participants to embed healthier home practices and sustain improvements.

Summary

In summary, the programme's success was grounded in human relationships and adaptive structures. The commitment, empathy, and technical understanding of programme staff created the foundation for trust, while effective leadership, robust systems, and cross-sector collaboration ensured the model could operate consistently at scale. Families' own accounts reinforced these findings, describing how straightforward equipment, responsive communication, and supportive contact made participation easy and rewarding. Together, these factors demonstrate how a community-embedded, relationship-driven approach can deliver complex public-health interventions with both fidelity and flexibility, generating lasting behavioural change and confidence among participants.

Limitations

Several limitations should be considered when interpreting the findings of this evaluation. We detail the limitations for the quantitative data analysis first, before we outline some limitations resulting from the wider evaluation approach.

Quantitative data limitations

Linear mixed models (LMM's) are typically used in analysis for repeated-measures data because they handle differences within individuals and uneven observation times. However, the air quality monitoring dataset was too large (over a million sensor readings for 10 households) to run a full model. Attempts to run LMMs in SPSS were restricted by memory and processing constraints.

As a pragmatic alternative, daily aggregation was applied to reduce the dataset to one observation per person per day, and simple linear regression was used to examine temporal trends. This approach provides a reasonable first indication of direction and magnitude of change over time, but it does not fully account for individual-level random effects. It also assumes independence of observations, which may underestimate uncertainty and it may over-simplify complex trajectories, especially where trends differ between households. Therefore, the observed regression coefficients should be interpreted as average group-level trends, rather than precise estimates of household-level change.

To render the dataset analysable within available software limitations, minute-by-minute sensor readings were aggregated into daily means. While this substantially reduced noise and made trend detection possible, it also introduces some constraints, such as a loss of fine-grained temporal variation (e.g., peaks due to cooking, cleaning, heating) and the potential smoothing of short-term fluctuations that might be clinically or environmentally relevant. It is also built on the assumption that daily means adequately represent indoor exposure, which may not always hold.

Households differed in how long their devices were active and how consistently data were transmitted. As a result, some individuals had extensive monitoring over many months; whilst others had very short monitoring periods. This could introduce imbalance that can affect trend estimates. It should also be noted that the "number of days since measurement started" standardises time but cannot fully compensate for heterogeneous follow-up durations.

Real-world sensor deployments often result in incomplete or irregular data streams. In this dataset, some households had large gaps in data collection, whilst some readings (e.g., VOC) were absent for long periods. It was noted that missing data was not

randomly occurring and may reflect behavioural factors (e.g., unplugging the device). These issues may bias estimates of change over time.

The analysis relies on sensor readings collected under naturalistic home conditions. Limitations include a possible device drift, calibration differences, or temporary sensor obstruction; other household-level environmental factors (ventilation, window use, cooking habits, cleaning chemicals, occupancy) that were not controlled for, or environmental variability (season, weather) that was not included in the statistical models. As a result, the statistical findings reflect observed fluctuations, not necessarily causal effects of the intervention.

The regressions document whether values changed over time but cannot determine *why* changes occurred. Trend analysis alone cannot isolate the possible impact of the IAQ monitor, any impact of the home visit and educational intervention or broader seasonal or behavioural changes. There are also likely to be external pollutant exposures which may have influenced measurements. Additional modelling or qualitative integration would be needed to link air quality improvements directly to the intervention.

Qualitative data limitations

A limitation of the qualitative findings is that some sections of the report are based largely on insights gathered from a small sample of participants. This approach allowed us to explore people's experiences in depth, but it also means the results cannot be assumed to represent all stakeholders or settings. For this reason, the findings should be interpreted with some caution. In this sense, the findings are primarily intended to highlight key themes and perspectives that can inform ongoing learning and decision-making, rather than to provide definitive or generalisable conclusions. Further work involving a larger sample would help to confirm and quantify many of the insights highlighted in this report

Recommendations

The evaluation of the Healthy Air for Healthy Lungs Programme highlights a range of operational, relational and contextual factors that shaped delivery, engagement, and outcomes. The following eight recommendations synthesise these lessons and offer actionable insights to enhance the effectiveness, sustainability and equity of future programme implementation.

1. Put data-sharing and referral arrangements in place before the programme begins, so information can be shared smoothly between the programme partners, the NHS, and evaluation partners.
2. Use study designs that track change over time or compare groups (e.g., quasi experimental) to better understand whether the programme is contributing to changes in health or air quality.
3. Collect air-quality data across different seasons and housing types (e.g., older and newer builds), to help distinguish programme effects from normal day-to-day or seasonal variation.
4. Use established tools to measure behaviour change, so changes in household practices can be assessed more consistently.
5. Treat future programmes as opportunities for learning and improvement, focusing on what works, what can be refined, and how communities engage.
6. Design eligibility and recruitment criteria that can be adapted locally, allowing the programme to respond to different community needs and housing contexts.
7. Clearly define and standardise the education and support offer within the programme, combining air-quality feedback with practical, tailored advice for households.
8. Improve local visibility and ownership by aligning branding and communications across boroughs, ensuring the programme feels relevant and accessible in all areas.

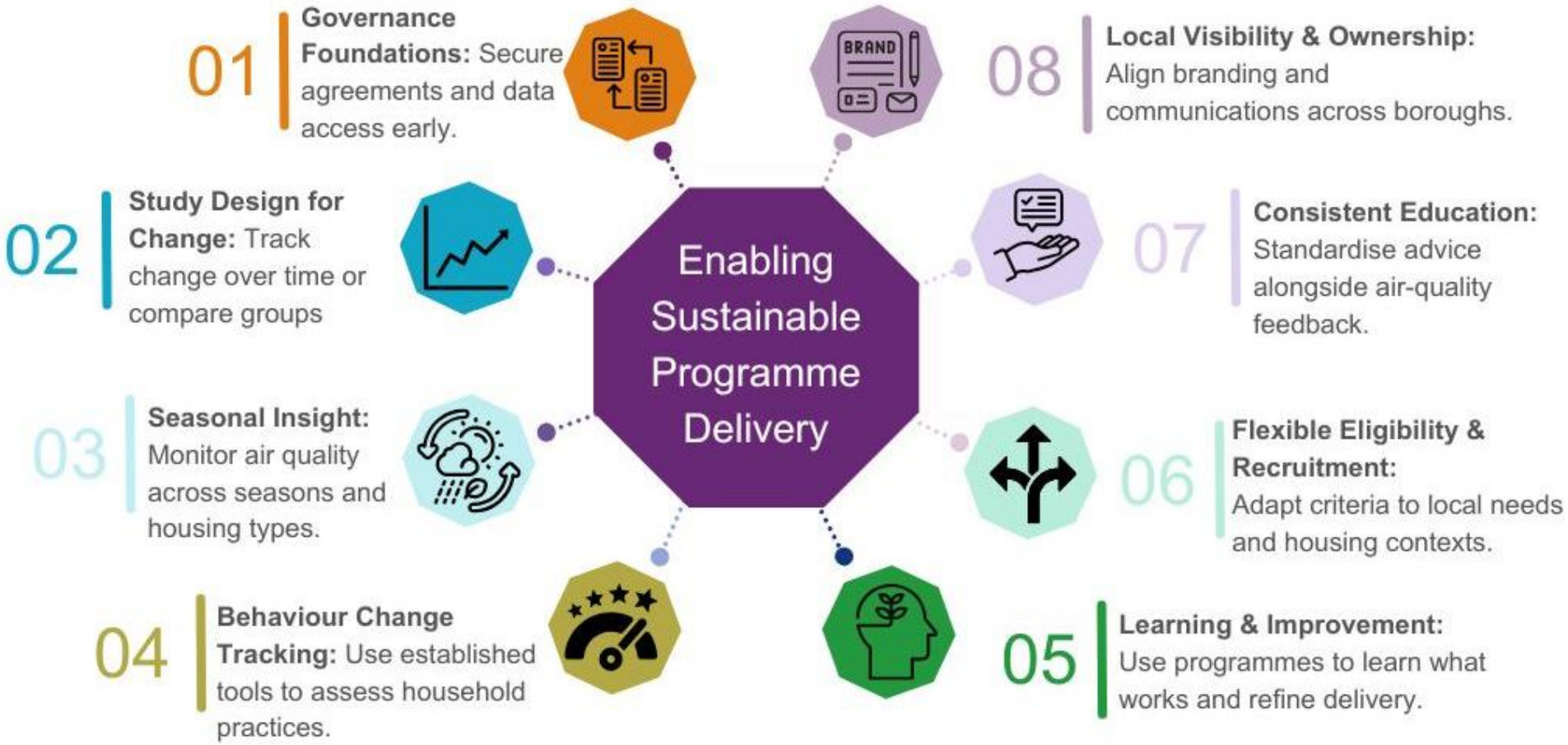


Figure 7. Recommendations for programme improvement

Glossary

- IAQ - Indoor air quality
- AQAPs - Air quality action plans
- AQMAs - Air quality management areas
- SCAs - Smoke control area's
- LSOAs - Lower-layer super output area (a small geographical unit created for statistical purposes)
- CO2 - Carbon dioxide
- VOCs - Volatile Organic Compounds (gases emitted from certain solids or liquids)
- NO2 - Nitrogen dioxide is a gas that is mainly produced during the combustion of fossil fuels
- PM1 - Particulate matter less than 1 micron in size
- PM2.5 - Particulate matter 2.5 micrometres or smaller in diameter
- LMM - Linear mixed modelling
- SPSS - Statistical software package used to analyse numerical data
- SD - Standard deviation (statistical measure that quantifies the amount of variation or dispersion in a set of values)
- p - The p-value in statistics measures how strongly the data contradicts a null hypothesis
- t - The t-statistic is a measure used in statistics to determine the significance of differences between sample means
- F - An F statistic is a value used in ANOVA (Analysis of Variance) and regression analysis.
- Cohen's d – A standardized effect size for measuring the difference between two group means
- IQR - The interquartile range is a measure of statistical dispersion, which is the spread of the data
- DEFRA - The Department for Environment, Food and Rural Affairs is a ministerial department of the government of the United Kingdom
- WHO-5 - The World Health organisation-5 Index is a 5-item questionnaire that is used for assessing wellbeing
- CIPHA - The CIPHA platform is a tool designed to enhance population health management by integrating data from various health and care organisations.
- AirThings - A Norwegian tech company that specialise in indoor air quality and radon monitoring

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Appendix A: Programme Logic Model

Context	Inputs/Resources	Activities	Outputs	Short term Outcomes	Intermediate Outcomes	Long term Outcomes
• High rates of paediatric asthma and respiratory illness in St Helens and Warrington. **• Poor indoor air quality in households, especially in areas of deprivation and social housing.** **• Challenges with household behaviours (e.g., poor ventilation, domestic burning) contributing to indoor pollution.** **• Health inequalities linked to environmental and socioeconomic factors.** **• Existing related projects (e.g., Warm Homes for Young Lungs, COPD support) have highlighted unmet needs.** **• Funding secured from DEFRA to address indoor air quality as a public health concern.**	• DEFRA Air Quality Grant funding (£405,227). • Indoor air quality monitors (AirThings devices). • Project delivery team (Wellbeing Service, Environmental Health, primary care partners). • Partnerships with NHS, PCNs, Torus Housing, Warrington Borough Council. • Access to CIPHA platform for health outcomes monitoring. • Educational materials based on NICE guidelines. • Referral pathways through GPs, schools, and housing associations. • Incentive vouchers, energy vouchers, and winter warmer packs. • Breathe Buddies peer support network. • Household Support Fund for targeted financial support.	• Identify and recruit eligible children (aged 2–10, inhaler-dependent) using healthcare data and referrals. • Install IAQ monitors in family homes and remotely track data through a dashboard. • Deliver home visits and telephone follow-ups to explain data and advise on behavioural changes. • Provide educational interventions about reducing indoor pollution (e.g., ventilation, reducing domestic burning). • Deliver household support (vouchers, winter packs, referrals to financial/energy advice). • Engage with families via surveys and interviews to assess awareness and behaviours. • Analyse health outcomes and IAQ data via CIPHA and AirThings dashboards. • Run awareness-raising campaigns and media activities (local radio, social media). • Continuous engagement with stakeholders through steering groups and progress meetings.	• 200 IAQ monitors installed in households across St Helens and Warrington. • 500 educational interventions delivered. • Real-time air quality data collected and monitored. • Multiple households receive financial or practical support. • Baseline, mid-term, and final surveys completed. • Quarterly and final reports submitted to DEFRA.	• Improved awareness of indoor air quality issues among participating families. • Changes in household behaviours (e.g., improved ventilation, reduced indoor pollution sources). • Improved indoor air quality measurements (e.g., reduced PM2.5, VOCs).	• Reduced asthma symptoms and inhaler usage in children. • Fewer unplanned healthcare visits and hospital admissions for respiratory issues. • Reduced inequalities in indoor air quality and respiratory health outcomes. • Strengthened local partnerships and cross-sector working.	• Improved paediatric respiratory health across the boroughs. • Reduced healthcare burden on the NHS and local services. • Improved housing conditions and living environments. • Scalable, evidence-based model for other local authorities.
Families will engage with the intervention and act on advice provided. **• IAQ monitors and data will accurately reflect household conditions.** **• Behavioural changes will translate into measurable health improvements.** **• Seasonal factors will be accounted for in data analysis.**						
Socioeconomic changes (e.g., cost of living crisis) impacting household behaviours. **• Variability in outdoor air quality influencing indoor readings.** **• Data sharing limitations between NHS and local authorities.** **• Varying levels of engagement from Warrington versus St Helens**						

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