SCSP Innovation Fund Case Study

Nooku

Summary

Nooku's pilot project aimed to improve the management of asthma and COPD among vulnerable populations in Glasgow through advanced air quality monitoring. By leveraging real-time data collection and AI-powered reporting, the project sought to empower individuals and healthcare providers with actionable insights, ultimately targeting improved condition self-management, reduced medical interventions, and better overall health outcomes.

Watch the Nooku case study video.

Key Collaborators and Stakeholders

The project was supported by:

- Respiratory Department, Royal Hospital for Children, Glasgow
- Community Respiratory Team (CRT), Glasgow Health and Social Care Partnership
- Glasgow City Council
- University of Strathclyde
- Smart Things Accelerator Centre (STAC)

Approach and Achievement

The project included deploying IoT indoor air quality sensors in 30 homes of individuals with COPD or asthma, developing a user-friendly app, and seeking feedback around the value of integrating data into healthcare workflows. Initial learnings have highlighted individuals' ability to improve condition self-management when empowered with data, and the need for seamless data integration and participant engagement to maximise impact. The project aimed to deliver actionable insights for both individuals and healthcare providers.

Introduction

Context and Rationale

Lung conditions are the third largest cause of death in the UK, yet they receive only 2% of public research funding. In Scotland, respiratory diseases like asthma and COPD cost the NHS over £500m annually and result in more than 15,000 hospital admissions each year. Glasgow's asthma and COPD rates exceed national averages due to high smoking rates, historic housing stock, and urban pollution levels. Poor indoor air quality exacerbates these conditions, with over 90% of homes exceeding WHO pollution limits. This project addressed the urgent need for improved management of respiratory conditions by leveraging real-time indoor air quality monitoring and actionable insights.

Project Objectives

- Empower individuals and healthcare teams with real-time indoor air quality data to improve condition management.
- Reduce hospital admissions through proactive interventions.
- Simplify complex sensor data into actionable insights via a user-friendly app.
- Inform broader healthcare policies with data-driven recommendations.

Problem Statement

Lung conditions are the third largest cause of death in the UK, yet they receive only 2% of public research funding. In Scotland alone:

- NHS Scotland spends **£500m** annually on lung diseases, including **£97.5m** on asthma and **£159m** on COPD.
- Over **368,000** people live with asthma, resulting in **5,000+** hospital admissions annually.
- COPD leads to **10,000** hospital admissions yearly, often due to poor indoor air quality, with **90% of homes** exceeding WHO pollution limits.
- Public Health Scotland 2023/24 "Respiratory Acute Admission" data highlights increasing trends when comparing with 2019/20 fiscal year (pre COVID-19). Children and Young People acute bed days have increased by **14.5%** across NHS Scotland. Glasgow City Region is significantly higher at **33.0%** - there is significant variation across the eight HSCP/Council areas (see Glasgow context).
- Public Health Scotland 2023/24 "Respiratory Acute Admission" data 1 highlights small reducing trends when comparing with 2019/20 fiscal year (pre COVID-19). Adults (All Age) acute bed days (**117** - population rate per 1,000) has reduced by **4.1%** across NHS Scotland. Glasgow City Region has seen an increase of **3.6%** (**143** - population rate per 1000) - there is significant variation across the eight HSCP/Council areas (see Glasgow context).

Glasgow City Region Context

- Adult (All Age) Respiratory acute total bed days (population rate per 1,000) vary significantly across the eight Glasgow City Region HSCP/Council areas – from Renfrewshire 116 to West Dunbartonshire 186. The NHS Scotland average is 117 – Glasgow City Region has a significantly higher challenge when compared with Scotland.
- Adult (All Age) Respiratory patients consumed 258,205 acute bed days across 2023/24. This represented 40.4% of Scotland's figure of 638,527 Respiratory acute bed day total.
- Children and Young People (<18- year-old) Respiratory patients consumed 15,710 acute bed days across 2023/24. This represented 44.3% of Scotland's figure of 35,436 Respiratory acute bed day total.
- Glasgow City Region Respiratory Children and Young People group saw a significant rise of 3,898 acute bed days, 87.1% of NHS Scotland acute bed day rise of 4476 when comparing 2023/24 (2019/20).
- Glasgow's asthma and COPD rates exceed national averages, attributed to high smoking rates, historic housing stock, and urban pollution levels

Project Description

Nooku's project aligned with the 5G Innovation Fund Connected Care and Wellbeing theme and aimed to improve asthma and COPD management through real-time indoor air quality monitoring and actionable insights.

Objectives

- Improve condition management by empowering individuals and healthcare teams with real-time air quality data.
- Reduce hospital admissions through preventative measures.
- Provide actionable insights via a user-friendly app, simplifying complex sensor data.
- Inform broader healthcare policies with data-driven recommendations.

Key Activities

- **Sensor Deployment:** Install advanced indoor air quality sensors in 30 homes with children suffering from asthma and/or older adults with COPD.
- **Data Analysis:** Integrate indoor and outdoor air quality data to identify trends linked to respiratory symptoms.
- **Mobile App Development**: Provide real-time data, personalised alerts, and symptom tracking for users.
- **Healthcare Integration**: Collaborate with healthcare teams to discuss the value of incorporating air quality data into care plans.
- **Feedback Loops**: Conduct surveys and focus groups to refine the proposed intervention.

Outcomes

1. **Health Improvement**: 15% fewer respiratory condition flare-ups in participants during the 4-month pilot.
2. **Increased Awareness:** Improved understanding of the air quality-respiratory health connection.
3. **Scalable Model**: A proof-of-concept for broader regional and national implementation.
4. **Policy Influence**: Data-driven insights to inform public health strategies.

Project Overview

The pilot project ran from October 2024 to March 2025, focusing on winter months when respiratory conditions worsen.

Timeline and Milestones

1. **October 2024: Planning and Preparation**
   - Finalise participant recruitment
   - Develop and test mobile application features
   - Onboard and train participants, and establish data-sharing protocols
2. **November 2024: Sensor Deployment**
   - Install sensors and begin baseline data collection
3. **December 2024–February 2025: Data Collection**
   - Real-time monitoring and analysis of indoor air quality
   - Mid-project review to assess and refine approaches
   - Healthcare stakeholder interviews and meetings
4. **March 2025: Analysis and Reporting**
   - Receive participant trial exit surveys and feedback
   - Complete final analysis and report findings
   - Present recommendations for scaling and future projects

Project Partners

The advisory panel for the project comprised several individuals of academic and medical backgrounds;

- **Dr Heather Price** - Senior Lecturer, Biological and Environmental Sciences (Environmental pollution and human health), University of Stirling.
- **Dr Marion Buchanan** - Retired GP with over 40 years of experience at the frontline of patient care.
- **Dr Malcolm White** - Clean Air Specialist, Global Action Plan.
- **Prof Frances Mair** - Professor of General Practice, Head of School, Health & Wellbeing, University of Glasgow.

We were additionally supported by organisations in a broader capacity;

- **Respiratory Department, Royal Hospital for Children, Glasgow**: Paediatric respiratory care for asthma participants.
- **Community Respiratory Team (CRT), Glasgow HSCP**: COPD management for older adults.
- **Glasgow City Council**: Participant recruitment, community engagement, and support throughout.
- **University of Strathclyde:** Trial guidance and governance.
- **STAC (Smart Things Accelerator Centre)**: Provided best practice guidance in managing the IoT Sensor deployment and secure data gathering/storage.
- **Arceptive**: Software development and data analysis.

Outcomes and Impact Targets

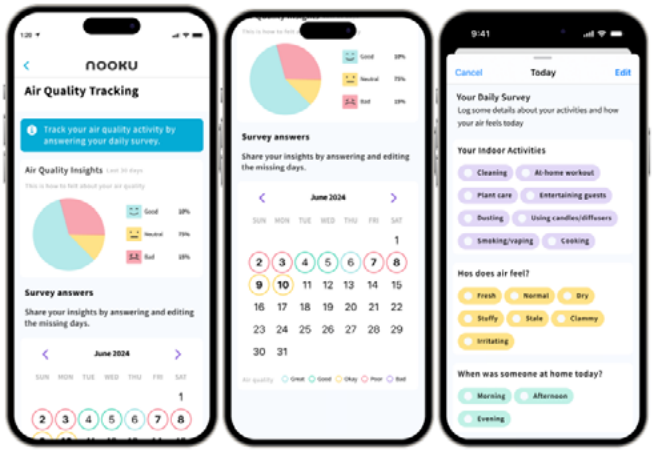
- **Measurable Outcomes**
  - **Hospital Admissions:** Reduction in respiratory condition flare-ups in participants which could potentially lead to hospital admission.
  - **Self-Management**: Improved user engagement with the app and proactive symptom management.
  - **Health Improvements**: Reduced exacerbations and enhanced quality of life.
- **Broader Impact**
  - **Health Equity**: Addressing disparities in respiratory care by empowering vulnerable populations.
  - **Proactive Care Integration**: Shifting from reactive to preventative approaches in respiratory health.
  - **Policy Influence:** Informing strategies for air quality interventions and respiratory health management.
- **Measuring Success**
  - **Hospital Data:** Comparative analysis of pre- and post-pilot hospital admissions.
  - **User Feedback**: Structured surveys and focus groups with participants and healthcare teams.
  - **Engagement Metrics:** App usage rates and symptom tracking compliance.

App Development

A new app feature was developed to enable users to actively track their air quality, activities, and overall feeling daily. This allows for the analysis of correlations between air quality metrics gathered and the reports on how the user felt in their environment.

The functionality allows for the correlation of gathered air quality data with user-reported experiences within their environment.

By enabling users to review their historical activity and feelings, the app facilitates the potential sharing of this valuable information with healthcare professionals. Furthermore, this data can be leveraged to generate a comprehensive summary and calendar heat-map, visually representing the patterns and frequency of a user's respiratory condition flare-ups. This visual representation can be an invaluable tool for both users and healthcare providers in understanding and managing respiratory conditions.



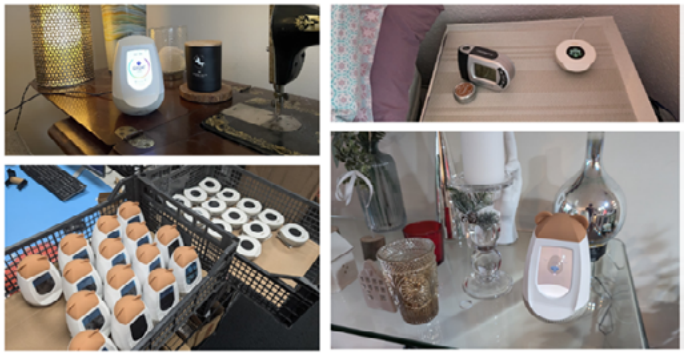
Sensor deployment

The sensors deployed were nooku's own innovative devices, specifically designed for comprehensive indoor air quality monitoring and user engagement. The devices are capable of monitoring temperature, humidity, Volatile Organic Compounds (VOCs), Nitrogen Oxides (NOx), Carbon Dioxide (CO2), and Particulate Matter (from PM1.0 to PM10).

Each participant received two devices to provide better coverage across both living and sleeping areas. A wireless modem was also provided to ensure reliable data backhaul which would not impose on the participant's own home network

The 30 participants were free to interact with the products as much or as little as they liked. Participants' primary responsibility during the trial was to complete the in-app daily surveys.

Deployment often involved setup of the products in participant homes to be carried out by nooku personnel. This served as an opportunity to engage people in the nuances of their conditions and their first-hand experiences with related healthcare.



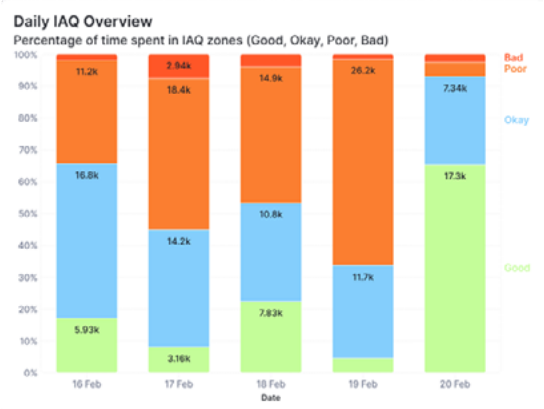
Data Analysis (Sample)

The chart below highlights the indoor air quality data for one selected participant over a five-day period. The participant, compared to previous periods, had reported a "streak" of neutral and bad "feeling".

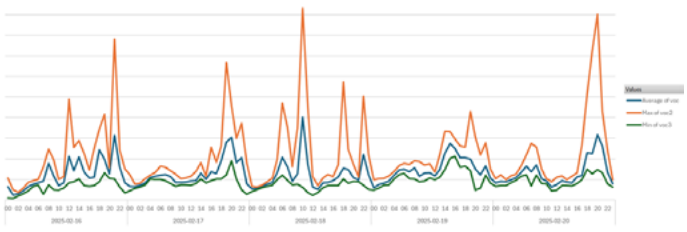
Reported "How did you feel"

16th February 2025: **good**
17th February 2025: **neutral**
18th February 2025: **neutral**
19th February 2025: **bad**
20th February 2025: **neutral**

Looking at the data in detail, it can be observed that on the days that the participant did not feel well, the general IAQ was poor or bad for at least 50% of the day.



Focusing on VOC and PM10 in the participants' home, it can be observed that a high frequency of VOC spikes preceded the "bad feeling" on the 19th of February.



At the same time the PM10 levels in the home were significantly higher, i.e. almost double the weekly average on the 19th of February.

This sample data represents a theme that was observed throughout the data analysis phase. Overall Indoor Air Quality (IAQ) is a complex interplay between different environmental factors and pollutants. At a high level the IAQ can provide an indication of how the participant might feel (regarding their respiratory system), and more detailed data like PM2.5 and VOC can now help to perform a root cause analysis and provide more tailored guidance to improve occupants' indoor air quality.

Through use of this form of data analysis in future, it is hoped to be possible to predict respiratory condition flare ups in advance with the aim to warn occupants to take preventative action.

Stakeholder Feedback

Key Insights

During the project, in communication with participants, practitioners, and academics, key insights were gathered which highlight the value of indoor air quality information for both individuals and medical professionals.

- The requirement for a more holistic approach to respiratory healthcare was acknowledged by both patients and doctors. Some participants reported more interest in a holistic approach from some doctors in recent years.
- The first point of contract for respiratory care is GP practices. More work is needed to explore how information can add value while reducing burden on health services. Anecdotally, one GP surgery was concerned about giving patients this data due to the risk of increased pressure on them to contact councils or housing associations to intervene in social housing issues, thereby increasing their already heavy workload during the busiest months of the year.
- Empowering patients with information to better take preventative action for condition management does appear to be a valid approach; A recent study from Dr Amy McCarron at the University of Stirling showed that 90% of household pollutants can be reduced through behavioural change. https://pubmed.ncbi.nlm.nih.gov/38609513/
- Pilots to integrate outdoor air quality data into the Epic EMR for childhood asthma care are underway, potentially paving the way for indoor air quality integration. https://www.ukcleanair.org/2022/12/23/great-ormond-st-childrens-hospital-takes-air-pollution-monitoring-to-the-next-level-empowering-clinicians-to-inform-and-support-their-patients-on-the-associated-health-impacts/
- There may be potential for IAQ monitoring as part of pharmacist's home care trial for COPD management.

Participant Exit Survey Statistics

A survey was conducted at the end of the trial to understand the impact indoor air quality monitoring at home had on participants' behaviour and respiratory health.

73% checked their air quality data one per day or more

43% noticed a correlation between reports of poor air quality and their respiratory symptoms

36% said that access to air quality information helped manage their respiratory conditions better

28% noted fewer respiratory condition flare-ups during the course of the trial

57% noted an improved awareness of air quality and links to their respiratory condition flare-ups

50% actively made changes to their home environment to improve their indoor air quality

7% improved their medication management through more proactive control of their air quality

Participant Testimonials

As part of the exit survey and trial conclusion participants were asked to make comments on their experience in their own words. Listed below is a small collection of that feedback:

"My son is obsessed by the bear and checks on it every morning. He's been taking much more of an interest in his Asthma management since it's been installed."

"We've found the air quality monitor has been really interesting to see how the air is throughout our house and have noticed a correlation between poor air quality and increase in respiratory symptoms."

"The most beneficial thing about Nooku is that it takes something completely invisible and makes it actionable. As a dad of a child with asthma, the concern about whether our home environment is hindering her is real - but with a Nooku in her bedroom I know if something spikes and I know I can do something about it. Nooku gives us some peace of mind!"

"I feel this device has helped massively with our general knowledge of the air quality, which is vital for people with respiratory issues, in particular my son whose issues are bigger than mine, so I think it's wonderful."

Challenges and Opportunities

Several challenges were encountered during the project, which all provided valuable insights for future initiatives.

- Nooku has previously delivered several successful pilot projects with various focuses, however, this was the first project nooku has carried out with a specific focus on respiratory healthcare metrics for success were more difficult to set. A target of 30 households was deemed reasonable based on the magnitude of past trials, however the effort in recruiting participants of a specific demographic and health situation was significantly more challenging. Despite this a full cohort was eventually recruited through several channels and partners, existing and new.
- Some older participants required more help to interact with the technology, sometimes finding it tricky to navigate the mobile app or resolve small technical problems independently. This has been a valuable experience and fed into our continuous product development process to ensure a universally inclusive user experience.
- One limitation in data analysis was the lack of granularity available for outdoor air quality data in the Glasgow City region. For example, only 8 outdoor air quality monitoring stations exist within the entire Glasgow City Council area, which limits analysis as the air quality even between adjacent streets could vary significantly due to several factors.
- Finally, limited adherence to the necessary daily surveys by some participants was witnessed despite regular in-app reminder notifications. In future this may not be an issue for patient care if only the collected air quality data matters, but during the trial this rendered a small portion of indoor air quality data collected not useful for correlation analysis. In future it would be worthwhile to design a trial protocol that does not place so much responsibility on the individual participants who often have busy lives and other priorities.

Sustainability Plan

Nooku's initiative is designed for scalability and long-term impact:

1. **Funding Expansion**: Leverage pilot results to secure support from government initiatives like the UKRI Clean Air Programme.
2. **Broader Adoption:** Collaborate with housing associations to install sensors in social housing, targeting high-risk areas.
3. **Policy Advocacy**: Use pilot data to advocate for air quality standards and funding for preventative respiratory care.
4. **AI Advancements**: Continue developing the AI-powered respiratory health platform, enhancing predictive and preventative capabilities.

Notes

- **Public Awareness**: Highlighting the impact of indoor air quality on respiratory health through public engagement.
- **Existing Successes**: Build on Nooku's previous pilot studies in schools, homes, and government buildings.

Conclusion

The Nooku pilot project successfully demonstrated a transformative approach to managing asthma and COPD by addressing the critical role of indoor air quality. Through the implementation of advanced indoor air quality sensors, real-time data analysis, and a user-friendly app, the project empowered participants and healthcare providers to take proactive steps in preventing exacerbations.

Measurable improvements in self-management and overall health outcomes were achieved, indicating the potential for scalable and sustainable interventions. The project also provided crucial insight to inform public health policies and highlighted the importance of integrating environmental health considerations into routine respiratory care.

The insights gained from this pilot will serve as a foundation for broader implementation across Glasgow and beyond. By scaling sensor deployment, advocating for supportive policies, enhancing the platform with AI, and engaging with communities and professionals, Nooku aims to establish a data-driven model that improves respiratory health outcomes, reduces healthcare costs, and enhances the quality of life for vulnerable populations.

The project's success underscores the value of innovative technology in addressing public health challenges and paves the way for future advancements in preventative respiratory care.

Find out more about the project on the Glasgow City Region website.

Acknowledgements

Nooku extends its gratitude to the following partners and contributors for their invaluable support in delivering this project;

- **Department for Science, Innovation and Technology (DSIT)**
- **Glasgow City Council**
- **Respiratory Department, Royal Hospital for Children, Glasgow**
- **Community Respiratory Team, Glasgow HSCP**
- **University of Strathclyde**
- **University of Stirling**
- **Arceptive**
- **STAC Accelerator**
- **5G Smart and Connected Social Places Fund within Glasgow City Region (GCR)**

Nooku also thanks the participants and their families for their involvement and feedback, which have been instrumental in shaping the success of the project.

Next Steps

Building on the success of this pilot project, Nooku will pursue the following steps to scale and enhance the intervention:

Scaling Across Glasgow and Beyond:

- Expand sensor deployment to more homes, targeting high-risk populations in additional regions.
- Collaborate with housing associations to integrate air quality monitoring into social housing initiatives.

Policy Advocacy and Funding:

- Use the pilot data to advocate for public health policies that prioritise indoor air quality as a key determinant of respiratory health.
- Seek funding through government initiatives like the UKRI Clean Air Programme and explore private investment opportunities to support further R&D.

Enhancing the Platform:

- Continue improving the mobile app based on participant feedback, adding features such as advanced AI-powered predictions and tailored health advice.
- Exploring integration of indoor air quality data with additional healthcare tools and systems to support a seamless user experience.

Community and Professional Engagement:

- Host workshops and seminars to share findings with healthcare providers, policymakers, and community leaders.
- Increase public awareness about the health impacts of indoor air quality through targeted campaigns.

By implementing these next steps, Nooku aims to establish a scalable, data-driven model that improves respiratory health outcomes, reduces healthcare costs, and enhances the quality of life for vulnerable populations.