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HIGHLIGHTS ...

Respiratory Life Stories - Jo Shakespeare

Reinterpreting Pulmonary Function Tests: Clinical Impacts of
Shifting from Race-Specific to Race-Neutral Reference equations

In Memory of Dr Duncan CS Hutchison



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First word

Dear Readers,

Welcome to the spring edition of INSPIRE. We have a bumper-packed issue with something for everyone.

I have once again picked out some of my favourite **conference abstracts** and asked the authors to develop them into full articles for this edition. Rhys Tudge and Andy Pritchard kindly agreed, and I am very grateful for their efforts. They have produced two excellent pieces that will be highly relevant to all departments in the current climate.

We also have our regular features, including **'Lab in the Limelight'**, which offers an insight into the expanding Paediatric Respiratory and Sleep Physiology Department at Leicester Children's Hospital, led by Joe Madge. Our esteemed Chair, Dr Joanna Shakespeare, spent some time chatting with me about her life and career for **'Respiratory Life Stories'**. **'Fresh Air'** showcases one of our recent STP graduates, Isobel Briggs, and her work on a pilot lung cancer screening project. **'On the Blower'** brings news of recent events, regional group updates, and manufacturer updates.

We also include a special **'In Memory'** article dedicated to a giant of respiratory medicine and physiology—Dr Duncan Hutchison. His son, Peter, and Adrian Kendrick generously provided the content to celebrate his life and his immense contribution to our profession.

As always, thank you to the editorial committee for their diligent work, and a warm welcome back to my eagle eyed deputy, Vicky MacBean, returning after a well deserved maternity leave.

I am always on the lookout for new articles and content so please get in touch if you would like to contribute to future editions of the journal.

As many of you will be preparing to travel to Belfast for the 50th anniversary conference, why not download your copy of INSPIRE and have it to hand while enjoying a Guinness over in the Emerald Isle.

Paul Burns

ARTP INSPIRE Editor

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A Word from the ARTP Chair

Dr Joanna Shakespeare

ARTP Honorary Chair



Hello and welcome to the first edition of INSPIRE for 2026. As I write this, it is Healthcare Science Week — a week where we celebrate the amazing work that you all do and look to raise awareness and recognition of the roles and responsibilities of Healthcare Scientists. As Chair, my commitment to ARTP is driven by a deep belief in the value of our profession and the impact it has on patient care. Respiratory and Sleep Healthcare Scientists play a vital role across the diagnostic and clinical pathway, and it is essential that we continue to strengthen our professional identity, standards, and opportunities for development. Through the work of the ARTP committees, I strive to support our members, advance education and training, and ensure that Respiratory and Sleep Science remains recognised as a key part of the Healthcare Science workforce.

A lot has happened since my last “Word from the Chair.” We launched the all-new ARTP website at the end of January. This new website will provide us with much improved functionality and a much better membership experience. There is still work to be completed before the website is fully updated and fully operational; however, I am sure that you will agree that it is already a significant improvement. Please look for membership updates over the coming weeks regarding content and the new member forum. If I could request that members regularly update their personal membership profile, this will allow us to better understand our membership as a whole.

The National Strategy Day was held in Birmingham on 12th December. The event was an enormous success, with excellent feedback from delegates. This year, we heard about the hard work of our Sleep, ED&I, Paediatrics, and Communications committees. We also had talks on innovation, efficiency, and alternative diagnostic pathways. I would like to acknowledge one particular presentation by Isobel Briggs, who delivered a very interactive, thought provoking and memorable presentation on neurodiversity in the workforce. We hope that we will be able to work with Isobel to build on this presentation, alongside the ED&I committee, to develop resources for the membership. As always, we are incredibly grateful to the twenty-one manufacturers who attended and supported the event. As we start to prepare for NSD 2026, please feel free to contact us with ideas for future presentations or workshops.

I had the pleasure of attending the Academy for Healthcare Science Honorary Fellowship awards in London on 3rd March, where three of our members were awarded Honorary



(L-R) Brendan, Julie, Kelly

Fellowships in recognition of their exceptional contribution to Healthcare Science. Professor Brendan Cooper, Dr Julie Lloyd, and Kelly Pauley were all recognised for their leadership, dedication, and lasting impact on the Respiratory and Sleep Science profession and on patient care. Huge congratulations to you all. As they prepare to retire, I would like to take this opportunity to

acknowledge the role that Brendan and Julie both played in my formative years as a Respiratory Physiologist and thank them for their mentorship and support.



(L-R) Julie, Jo, Brendan

The Executive Board continues to work towards achieving the objectives of the current ARTP strategy. We provided an update on how we are progressing at the recent NSD but will provide a further update at the AGM in May. Most recently, we have published our ARTP Standard on the appointment of Consultant Clinical Scientists. This follows on from our position statement on professional registration and reporting time standards. These documents are designed to support our members, providing the evidence needed for appropriate staffing of our services. All our standards and position statements can be found on the ARTP website.

A new initiative is the development of specialist interest groups (SIGs). Our first SIG on breathlessness pathways is being launched on 29th April, 12:00–1:30pm. This online forum has been designed to bring together and support ARTP members involved in the development, delivery, or planning of diagnostic breathlessness pathways. Chaired by our non executive director Dr Helen Ward and led by our Standards Leads Andrew Pritchard and Joanna Purvis, these sessions will provide a mix of presentations and facilitated discussion with Q&A. We are also looking to develop and implement a SIG for the Optimal Sleep Pathway in the next few months.

Finally, I am extremely excited about the plans for our 50th Anniversary Conference in Belfast on 21st and 22nd May 2026. Once again, we have had a really good response to our call for abstracts, and authors should now be aware of their decision. Our programme is fully populated, and we are making final plans for the social events and 50th celebrations. I hope that as many of you as possible can attend.

As always, I would like to encourage members to communicate with myself (chair@artp.org.uk) or specific Committee Chairs (via admin@artp.org.uk) as much as possible. Please feel free to ask questions or raise comments or concerns where required.



Respiratory Life Stories

Dr Joanna Shakespeare

Interview with INSPIRE Editor - Paul Burns

I first began to get to know Jo when she asked me to join the ARTP Education Committee as the paediatric representative back in 2013. I accepted without hesitation. From that point on—seeing Jo in action at board meetings, conferences, and CPET courses—it became immediately clear that she was extraordinarily efficient, relentlessly organised, and possessed the kind of natural leadership qualities that make a lasting impact.



Her journey to becoming Chair of ARTP has not been accidental; it is a story built on hard work, passion, and unwavering determination. Jo has carved out a remarkable career in healthcare science, and she remains a powerful inspiration to anyone striving to develop professionally — especially women in our profession, where strong, visible role models matter.

And yes — while Jo can be a tough nut to crack and (occasionally!) slightly scary during business discussions, on a personal level she is one of the friendliest, warmest, and most genuine people you could ever spend time with. I've had the pleasure of experiencing this many times, whether teaching alongside her, spending time at conferences, or catching up during professional meetings.

This is Jo's story.

Tell me about your early life, school and studies

I grew up in Birmingham—"a Brummy through and through"—attending the local school, and I had a part-time job working at Greggs during my studies. When I finished my A levels I hadn't got the results I wanted, so I eventually went full-time in Greggs while returning to night school to do another A level and GCSE.

Although I hadn't yet found my future profession, the seeds were already being planted. During my A-level human biology project, I used a water-based spirometer. When I did my night-school A level in sports science, I performed VO₂ max testing—long before I realised where my career would take me. I was heading in the respiratory direction without even knowing it, but this came in handy when I had my first interview for a respiratory post! I chose sports science because I was into sports—particularly football, as I became a season-ticket holder at Aston Villa when I was seven years old. My sister (a Respiratory Physiologist in Birmingham) and my dad both played football at a good level.

How did you get into respiratory?

I had considered physiotherapy and nursing, but a newspaper advert changed everything. It was for a trainee on the West Midlands Technical Officer Programme, and I applied for both respiratory and cardiology. I got interviews for both, but I interviewed for respiratory first and was offered it immediately—so I cancelled my cardiology interview. That's where it all started.

I began the two-year BTEC in Medical Physics and Physiological Measurement, undertaking placements in physiological and medical physics specialties whilst based in Respiratory. Once I finished the training programme there was no guaranteed job—you had to apply for one. I was lucky in that I trained under the legendary Professor Sue Hill. She told me she would have an MTO1 post available when I finished. She not only recruited me but recognised my potential and pushed me to grow—enrolling me in the clinical science degree and then management training. If there were opportunities available, Sue got you onto them. This was prior to Brendan Cooper starting in Birmingham—so I was there before him!

I worked with Sue in Birmingham for around seven to eight years until she left to work for the Department of Health. I started in Birmingham in 1994 and stayed until 2004. During this time I got married. My time in Birmingham was formative: small teams, big ambition, and an environment where I could build both my technical skills and my leadership identity.

Did the department in Birmingham grow in that time you were there?

Yes, it became a big department, and I had worked my way up to MTO5. Brendan arrived from Nottingham around 2003. Brendan was the overall service lead, and I was in charge of the day-to-day running of the department. I was really enjoying both the job and my career. Part of my rapid progression was down to Sue. When the Clinical Science degree started in 1996, she put me on it, which I completed in Surrey. It was similar



to what the apprenticeship model is now—doing the academic qualification whilst working in the lab. She also put me forward for a management qualification.



Early team Photo from Birmingham.
Back row L-R: Theresa McAuley, Jodie Hunt, James Stockley
Front row L-R: Lindsey paddison, Jo Shakespeare, Clare Newall

How did you initially get involved in the ARTP?

Sue put me forward to join the Education Committee in 2004 as she was leading the ARTP at the time. I became Chair of Examinations as part of the committee. That would have been when I asked you to come on board as the paediatric representative for examinations/education. Julie Lloyd was Chair of the Education Committee at that point. I took over from Julie as Chair of Education in 2013 and stayed in the role until 2019. It was a big job, as education is one of the fundamental purposes of ARTP, delivering and overseeing high-quality training in respiratory and sleep physiology.

Tell me about your move from Birmingham to Coventry

I was running the day-to-day service in Birmingham but was looking for a new challenge and liked the idea of shaping my own service. I also wanted to go somewhere in its infancy, where I could develop and improve the department. Coventry offered that opportunity, as it was a small, basic-level service at the time. I knew it was moving into new premises, and one of the consultants I had worked with in Birmingham had moved there, giving me additional support. I actually dropped down a band when I moved, so it was a gamble—but I knew there was potential to develop and expand the services, which could then lead me to a higher banding.

Tell me about expanding the services at Coventry and your biggest challenges

The first thing to do is know who to make friends with, because you need someone in every department. For example, IT is a really important one, as is the commissioner. It's all about building relationships. You also have to bring the whole team along with you. I am a dynamic individual and was trying to introduce a lot

of change, so it can be hard initially to sell this to a team of people who are happy with the way things are. It's about getting people to come along on that journey with you and having a long-term plan. You need to take small steps and tick things off as you go along, because you can't make huge sweeping changes in one go. So, it was an evolving picture for quite a long time.

You need to prioritise what you want to get done. When I started, sleep was the priority because they were sending all their patients for private diagnostics, but there was no CPAP service to treat them. Once I got that up and running efficiently, I then focused on the CPET service, because when I arrived they had a treadmill that was being used to store boxes and had never been used! I managed to secure funding to add a bike. Therefore, sleep and CPET were the areas I needed to focus on first.

To give you an idea of the growth of the department: there were four staff when I started, and now there are around thirty.



The Coventry team during gaining their IQIPS accreditation

Was it difficult to get the funding to expand these services in terms of equipment and staffing?

It all depended on which part of the service it was. For example, with the CPET kit, I managed to expand it because we received the tariff, so I was able to base a business case around that. With the oxygen service, it was different because the commissioners were funding it directly. They paid for staffing, as we were able to show that we could save money by fixing inappropriate oxygen prescribing. I think you just have to flex depending on which service you want to deliver.

The most difficult one to get agreed was the NIV service. Because the service was being delivered elsewhere, it wasn't seen as a problem by the NHS managers of the hospital. But from a patient perspective, it was difficult, as they were having to travel around 30 miles from Coventry to Leicester. In the end, we created a video with an MND patient who was doing this journey, and he emphasised how difficult it was for him. This was enough for the people holding the purse strings to understand the impact it would make. It showed the power of the patient's voice.



Jumping back a bit slightly, when did you have your children and how did this affect your working life?

I had moved to Coventry in 2006 and left to have my boys in 2008. As you know, I have twins—James and Henry. I think it helped having the two at once! By the time I had the boys, I had a lot of experience and was leading my own service in Coventry, but it is harder for women who have children earlier in their career to keep progressing. I had already reached the level I thought I was going to reach, so I was a little more comfortable, although the staff who had to cover for me whilst I was off might not quite agree!

When I returned after having the boys, I went to three days per week. Remember, two kids mean double the childcare costs! My mum helped out, and my husband, Nick, dropped a day to look after them as well, so they only needed to go to nursery one day per week. I was Vice Chair of Education when I went off on maternity leave, and I was due to become Chair when I returned. But with the boys being so little, I stepped back and took on Examinations instead until they were a bit older.

What was it like taking on the education chair role?

I really enjoyed it, but it was hard work. It was full-on, but at that time I think we had the hardest-working committee. Lots of changes happened with the discontinuation of the Clinical Physiology degree and the introduction of Modernising Scientific Careers. This meant the end of the ARTP Part I and Part II qualifications, as they were embedded into the Clinical Physiology degree. This left a big gap, so we developed the Practitioner and Associate examinations. I think as a professional body, we do education very well. We have maintained the value of the professional body exams—probably more so than some of the other physiological disciplines—and it is nice to see that trainees are still undertaking them in their droves.

Tell me about your career progression on from this, with STP equivalence & HSST

Once the Scientist Training Programme was rolled out, allowing physiologists to gain statutory regulation through the Health and Care Professions Council (HCPC), I decided to go through the equivalence process. I was the first physiologist to go through this and achieved my equivalence in 2013.

I started my Higher Specialist Scientific Training (HSST) in 2016 while I was still Head of Respiratory and Sleep in Coventry, but I had built up a good team, so the department ran smoothly. The HSST was a lot of work. You get one study day per week, which helps. The first two years were at Manchester University and focused heavily on leadership and management qualifications, which I really enjoyed. I learned a lot, particularly about myself as a person—there was a lot of reflection involved. At the beginning of the module, I remember

thinking I would never be able to write the assignment, but by the time it came around I was actually able to do it quite well.

Following on from that, you complete the specialist modules, which were based at Manchester Metropolitan University. One of the problems was that unless you were sitting in a medical consultant's clinic, you couldn't fully experience the learning, as it is quite self-directed. It's not the sort of content that can be easily taught in a classroom. Having prior experience with acute NIV work and time on the wards stood me in good stead. For many of us with physiology backgrounds, we are very outpatient-focused, so we don't get much exposure to acutely unwell patients. My time on the wards gave me that experience, which was great. I learned skills such as examining a patient and asking the right questions. Time management is important—checking off each module as you go along—especially as you also have a portfolio of evidence to build.

How has your job changed since finishing the HSST?

It has changed quite significantly. I no longer manage the physiology department; I now sit separately from them within the medical group alongside the respiratory consultants. I share an office with a respiratory consultant and have my own sleep and NIV clinics. I also continue to run a monthly CPET clinic so I can maintain my skills—mainly because I still really enjoy CPET. My HSST thesis was in this area, and I continue to teach on the ARTP CPET course.

I have my own patient list and clinics. I triage sleep apnoea referrals and run a complex sleep clinic—for example, suspected narcolepsy or parasomnia. We have access to full PSG, MSLTs and actigraphy, so I am able to refer patients for those tests. For my NIV clinic, I manage a large cohort of MND patients, lots of obesity hypoventilation and some COPD. I have just started running an NIV clinic at the hospice in Stratford for MND patients who struggle to travel. It works very well, as nurses, physiotherapists and occupational therapists are all there simultaneously—so it's a bit like an MDT. Funnily enough, it's at the "Shakespeare" Hospice in Stratford, which feels quite fitting!

Having no staff to manage means far fewer HR responsibilities, but it can sometimes feel a little lonely. I've gone from working with a big team to working on my own for large parts of the week. However, I work closely with the other sleep and NIV consultants. There are three of us who collaborate and run MDTs. Despite this, I am still quite separate from the consultants, so I don't fully fit anywhere anymore—which you either embrace or occasionally find difficult. It honestly depends on what day of the week you get me! Sometimes I feel a bit isolated; other times it's nice to put my head down and work autonomously.

The designated clinical time is really enjoyable. As I moved up the ladder, managing the department meant



losing a lot of my clinical time due to managerial duties. The HSST role has allowed me to reverse that and be far more clinical than managerial.

After you completed HSST, you took on the role as ARTP Chair. How have you found it?

I've really enjoyed it. It helps enormously having Matt Rutter as Vice Chair—he has been a great support. Without him, it could get quite lonely, and it's much easier to make decisions and bounce ideas off someone when you have a strong Vice Chair.

I think I've been quite lucky with the timing, as there have been a lot of changes happening that I've been able to get my teeth into. I strive to improve the profession and the services we offer, and the role of Chair has given me the platform to do this. It can sometimes get very busy and overwhelming, as you often have a large list of tasks to get through. Other times, things are quieter. One of the big projects was the new website, which was all-consuming for a while. Once that was complete, I could tick a few more things off the to-do list—until the next big thing, which will be the conference!

Who has been inspirational in your life and career?

I would have to say Sue Hill. She gave me my first job in respiratory and, as I mentioned, pushed me continuously to move on to the next step of the ladder—which I also think came naturally. She really helped me develop my career.

When I first started in the Midlands, one of the people I really looked up to was Julie Lloyd. I remember being a junior, attending a meeting and seeing this confident (she insists she's not, but she certainly appeared so!) senior, knowledgeable female leader. She was Head of Department and had a great depth of knowledge in respiratory physiology. I saw that and thought, "This is what I want to be like."

Brendan Cooper, as my lead and Chair of ARTP at the time, also did a lot to support my career. He boosted my confidence and helped me grow.

In my current workplace, Dr Asad Ali—one of our consultants and now the Deputy Medical Director at our Trust—has been inspirational. In many ways he has been my mentor since I moved to Coventry and helped me get into the role I now hold. If I ever need to go to someone, he is the person.

What age are your boys? How is family life?

The boys are now nearly eighteen—time flies! My family is very supportive. My husband, and my mum and dad, have been great through the years. You know what it's like—you need an understanding partner, as we work in a profession where we can't always switch off when we come home. Having someone who supports you when you have extra work to do, or need to travel for a conference or course, is really important.

The boys are doing well. One is at college and the other is an apprentice joiner. They used to fight a lot when they were younger, as they are very different, but they get on really well now.

What does the future hold for Dr Jo Shakespeare?

I want to stay in my current role for the next five years. I sometimes wonder about a role with the Department of Health, or perhaps something more teaching-focused—or maybe I'll stay as I am. I think it will depend on where the NHS goes in that time. I'll reflect over the next five years and then evaluate where I am.

You don't seem to someone who will rest on their laurels. Tell me about your recent competitive running experiences.

I can't quite remember when I did my first half marathon, but I remember watching the London Marathon on television and thinking, I want to do this. So, I signed up for the Great North Run. The euphoria of crossing the finish line gave me the bug, and I went on to run several half marathons.

In 2021, I signed up to do "Race to the Stones", a 100 km ultramarathon which I completed over two days. It was an amazing experience, though it took my knees a while to recover!

I did consider doing another ultra this year, but I've only just got back into running. I've been doing a lot of CrossFit. I'm the type of person who needs a goal in the diary to work towards, so I might look at doing a HYROX event. I managed a 10k the other week and survived it, so there's still hope! I'm definitely someone who needs motivation—that's why CrossFit suits me, as everyone shouts at you!

**QUICK FIRE QUESTIONS****Favourite food & drink?**

Classic British food done well in a nice restaurant. A cup of tea or a glass of wine.

**Celebrity crush?**

Idris Elba

**Favourite film?**

Ferris Bueller's day off

**Nicknames?**

Shakey

**Favourite pastime?**

Watching Aston Villa play, Crossfit, cooking, going to the theatre

**Karaoke song?**

In a duet with Karl Sylvester - "Islands in the Stream"

Solo – "Local boy in a Photograph" by Stereophonics

**Favourite holiday destination**

Thailand or Croatia

**Favourite memory?**

Birth of my children, HSST graduation

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Reinterpreting Pulmonary Function Tests: Clinical Impacts of Shifting from Race-Specific to Race-Neutral Reference Equations

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Abstract

Pulmonary Function Testing (PFT) interpretation compares actual measurements with predicted values derived from a global dataset. In 2012, the Global Lung Function Initiative (GLI) developed race-specific reference equations for PFT interpretation based on this dataset, but the use of race and ethnicity has been questioned due to concerns about reinforcing health disparities. To address this, GLI introduced race-neutral equations (2022). This study evaluates the impact of transitioning from race-specific to race-neutral reference equations on PFT interpretations in a local patient sample. PFT data from 5,716 patients (Aged 18-95) were reanalysed using GLI global 2022 race-neutral equations and compared to GLI 2012 race-specific equations. Results were stratified by self-reported ethnicity (White, Black, Other/Mixed). The mean difference in FEV₁ Z-scores between race-specific and race-neutral equations was -0.31 [LOA: 0.08; -0.71] in the White cohort, 0.53 (LOA: 0.93; 0.13) in the Black cohort, and -0.06 (LOA: 0.36; -0.49) in the Other/Mixed cohort. Race-neutral equations resulted in lower FEV₁ Z-scores in Black patients, and higher in White patients. Minimal differences were observed in the Other/Mixed cohort. Race-neutral equations increased the prevalence of impairment by 1.9% in the White cohort, 11% in the Black cohort, and 0.65% in the Other/Mixed cohort. Overall, 8.1% of patients changed PFT interpretation. Adopting GLI 2022 race-neutral equations will significantly impact spirometry interpretation, especially for Black patients. Clear communication with clinical teams is vital

to ensure awareness of these changes. While this shift represents progress, further research, especially in more diverse cohorts, is needed to fully evaluate its clinical impact.

Introduction

Pulmonary function testing and predicted values

Pulmonary Function Testing (PFT) is an essential component of respiratory medicine and is widely used to inform patient care, assess and monitor respiratory conditions, screen for disease, and evaluate population health. Interpretation of PFT results involves comparing an individual's measured lung function to predicted values, which define the expected range of lung function in healthy individuals. These predicted values are derived from population-based datasets of healthy, non-smoking individuals and are used to determine whether measured lung function falls within a normal range.

The estimation of lung function typically relies on measures such as height, age, and sex. Height can serve as a proxy for chest size, although it is not a direct indicator of lung size. Age influences lung function due to physiological changes in chest wall elasticity and rigidity over time, while sex is an important determinant, with biological differences in lung structure. These variables, though imperfect, have been consistently used to improve the accuracy of PFT interpretation¹.

The final factor that has historically been utilised as a measure to estimate predicted lung function is ethnicity or race. In various fields of medicine, race and ethnicity have traditionally informed



clinical practice under the assumption that there are biological distinctions between populations. However, it is now widely acknowledged that race and ethnicity are socially constructed concepts, shaped by cultural, historical, and political contexts rather than innate biological differences². As populations become increasingly diverse and the lines between ancestral groups become more blurred, the traditional racial and ethnic classifications used in medicine become less precise and more controversial.

Historically, assumptions about ethnicity and its impact on pulmonary function led to the belief that there were observable differences in lung function between ethnicities, with non-White populations generally exhibiting poorer results than their White counterparts. This perception had potential clinical implications for these patient groups³. However, contemporary understanding emphasises that many factors influencing pulmonary function are more closely linked to social determinants of health rather than inherent ethnicity-based determinants⁴. The recognition that race and ethnicity are socio-political constructs reflecting shared geography, social and cultural factors, along with genetic ancestry, further supports this evolving perspective⁵.

The origins of race-based adjustments in pulmonary function testing can be traced back to the 19th century. Samuel Cartwright, a plantation physician and slave owner, claimed in 1840 that Black individuals had a 20% lung function "deficiency" compared to White individuals⁶. These early assertions, based on what we now recognise as racist ideologies rather than scientific evidence, contributed to the development of race-based adjustments in PFT interpretation.

In 1999, PFT data from non-smoking individuals with no known lung disease, collected as part of the third National Health and Nutrition Examination Survey (NHANES III) in the United States, were used to develop reference equations for normal pulmonary function in the three major ethnic groups: Caucasians (White), African Americans (Black), and Mexican Americans. Analysis of 7,429 datasets revealed that Black participants had lower average lung function compared to their White counterparts.

As a result, it was proposed that an "adjustment factor" of 12–15% be applied to the Caucasian reference equations when interpreting PFT results for Black patients⁷.

There have long been calls to discontinue the use of race and ethnicity in medicine⁸. Pulmonary function testing has become one of the most scrutinised areas in which race-based clinical adjustments persist⁶. Despite these concerns, race-adjusted reference equations continue to be routinely used in pulmonary function test interpretations, often without sufficient justification. This practice may inadvertently reinforce health disparities⁹.

Over time, researchers sought to explain observed differences in lung function across populations, initially attributing them to intrinsic biological factors. However, research has demonstrated that these differences are largely influenced by other factors such as socioeconomic and environmental determinants of health rather than inherent racial differences⁶. Given these complexities, the use of fixed racial adjustment factors in PFT interpretation is now widely considered inappropriate¹⁰.

Ensuring testing centres are consistent in PFT interpretation is crucial, as discrepancies in reference equations could lead to inconsistencies in diagnosis and management. The lack of a global, standardised method to interpret PFTs has led to considerable confusion and fuelled ongoing discussions about the correct interpretation of results¹.

GLI introduction

The Global Lung Function Initiative (GLI) was established in 2008 with the aim to develop international spirometry reference equations based on standardised lung function data. Its objectives included creating continuous equations across all ages using modern statistical techniques, accounting for variability due to standing height, sex, ethnicity, and age, and ensuring clinically useful PFT interpretations. The GLI equations were designed to be integrated into commercial spirometry equipment and to be able to provide a clear assessment of lung function relative to the normal range.

In 2012, the GLI established race-specific reference equations for spirometry in individuals



aged 3-95 years¹¹. These equations were the first of their kind, developed to standardize the interpretation of lung function globally.

The reference equations employed an innovative statistical approach known as Generalized Additive Models for Location, Scale, and Shape (GAMLSS). This method enabled the modelling of spirometric values across various ages and generates age-specific values for the lower limit of normal (LLN).

GLI 2012 dataset

The 2012 GLI equations were derived from 74,187 global records of healthy non-smokers (57% female) aged 2.5-95 years. This dataset was categorised into four ethnic groups: "Caucasian" (White; n= 57,395); Black (n=3545); North East Asia (n=4992) and South East Asia (n=8255). The grouping and breakdown of these ethnic groups can be seen in Table 1 and Table 2 respectively.

Table 1: Grouping of the original GLI 2012 dataset
Adapted from Quanjer et al. (2012).

Group	Country/Region
"Caucasian" (White)	Europe, Israel, Australia, USA, Canada, Mexican Americans, Brazil, Chile, Mexico, Uruguay, Venezuela, Algeria, Tunisia.
Black	African American
South East Asian	Thailand, Taiwan and China (including Hong Kong) south of the Huaihe River and Qinling Mountains
North East Asian	Korea and China north of the Huaihe River and Qinling Mountains

Table 2: Number and age ranges of participants used to derive GLI 2012 predicted values.

Group	Males		Females		Total
	N	Age (yr)	N	Age (yr)	
Caucasian (White)	25,827	2.5-95	31,568	2.5-95	57,395
African American (Black)	1,520	6-85	2,025	6.1-87	3,545
North East Asia	1,414	16-91	3,578	16-88	4,992
South East Asia	3,095	3.3-86	5,160	3.2-92	8,255
Total	31,856		42,331		74,187

The classification system used in this dataset has been critiqued for its broad and sometimes arbitrary groupings. For example, the "Caucasian" category includes data from regions as diverse as the US, UK, Switzerland, Algeria,

Brazil, Chile, Israel, Portugal, Sweden, Tunisia, Uruguay, and Venezuela, raising concerns about the homogeneity of the grouping.

Conversely, the Black category is limited to African American data from the United States, which is problematic given the significant genetic, linguistic, cultural, and phenotypic diversity seen across the African continent¹².

Additionally, the "North East Asian" category encompasses data from Northern China and South Korea, while the "South East Asian" category includes Thailand, Taiwan, Hong Kong, and Southern China, further complicating the regional distinctions. These classifications can appear inconsistent, as seen in the grouping of Algerians and Venezuelans together while differentiating between individuals from Beijing and those from Shanghai¹³.

Furthermore, the GLI dataset suffers from a significant lack of data from regions such as Sub-Saharan Africa, the Indian subcontinent, and Latin America, leading to an underrepresentation of global diversity.

Since many individuals were not represented by these ethnic groups, a composite equation was derived using the mathematical average of the other four race-specific equations (GLI-Other)¹⁴. However, due to the original dataset used for these equations being over 77% White, this approach was heavily weighted and did not address the disparities in pulmonary function.

Limitations of GLI 2012

Although the intent behind developing race-specific equations was to standardise lung function interpretation and account for variations across self-identified racial groups, these equations may perpetuate racial bias and inequality. By reinforcing the assumption of inherent biological differences, they risk exacerbating disparities in lung health outcomes, ultimately contributing to systemic health inequities⁵.

While some countries, such as Australia¹⁵, Norway¹⁶, and Germany¹⁷ found the GLI 2012 race-specific equations to be applicable to their populations, many others have reported that these equations are less suitable for clinical use¹⁸.

For instance, studies in Japan and Korea found that the North East Asian equations provided a



poor fit when applied to contemporary populations¹⁹. Additionally, data from India²⁰ and South Africa²¹ also raised concerns about the broader applicability of GLI 2012 race-specific equations. The age composition of the GLI 2012 dataset also includes relatively limited paediatric representation and differences in the starting age of some ethnic datasets, such as those representing North East Asian populations, which could affect the applicability of the equations across all age groups.

GLI global 2022

In response to these concerns, the GLI formulated a new GLI global race-neutral approach to the interpretation of lung function, which does not consider ethnicity, using the existing GLI dataset.

To address the underrepresentation of certain racial and ethnic groups, the data were reanalysed using an inverse probability weighting approach. This method ensured equal representation of race and ethnicity groups in the reference equations by assigning a weight to each data point based on the sex-stratified proportion of its corresponding group within the original dataset (White, Black, South East Asian, or North East Asian). As a result, greater relative weight was given to underrepresented groups, such as Black individuals, ensuring that each group contributed equally to the final equations⁵.

Despite the recommendation by both the American Thoracic Society (ATS) and the European Respiratory Society (ERS) to move to GLI Global 2022 adoption within UK pulmonary function departments varies¹. This may be due to factors including institutional policies and department awareness of the new standards.

Similar comparative studies

Baugh *et al*²² examine the implications of race-specific approaches for estimating lung function, highlighting their potential contributions to racial disparities. Their findings suggest that race-specific equations may underestimate lung function in African American individuals.

In a subsequent case-based discussion, Baugh *et al*³ explore theoretical scenarios in which the use of different PFT interpretation equations leads to varying outcomes in contexts such as employment, disability evaluation and cancer surgeries for Black patients. Notably, in a

hypothesised case of lung cancer resection, applying a race-neutral approach results in a shift in post-operative risk classification based on anticipated post-operative FEV₁%predicted falling below 30% versus above 30% with race-specific equations. This threshold is often used to determine surgical eligibility, meaning that under the race-neutral approach, the patient was more likely to be deemed a high-risk surgical candidate, and surgeons may have been less likely to recommend surgical treatment. This case highlights how changing reference equations can directly impact clinical decision-making and patient outcomes, underlining that interpretive strategies must be applied within the broader context of individual patient care rather than in isolation.

Beyond surgical decision making, concerns have also been raised about the transition to race-neutral PFT interpretation in occupational settings. Shifting from race-specific to race-neutral reference equations may disproportionately increase the number of people of colour deemed unfit for physically demanding occupations such as firefighting, mining, commercial diving, and military service. This shift may also have financial implications, including the potential for higher health insurance premiums for people of colour⁹.

Given that lung function is a strong predictor of morbidity and overall mortality²³, the impact of reference equations on prediction of long-term health outcomes is also being investigated. Authors examined whether race-specific reference equations improve the prediction of clinical events and mortality compared to race-neutral equations in a prospective cohort study of White, Black, Hispanic and Asian adults²⁴. PFT data from patients collected between 2004-2006 were analysed using both equations, and patients were then followed for clinical events until 2019. The authors conclude that there is no evidence that race-specific reference equations provide better predictive accuracy for clinical outcomes than race-neutral equations.

Burney and Hooper²⁵ provide further support for this, demonstrating that pulmonary function, when adjusted for age, sex, and height, predicts the same level of mortality for Black and White participants. These findings suggest that the use of separate race-specific reference equations is not justified.



On a larger scale, Diao *et al*²⁶ analysed longitudinal PFT data from 369,077 participants and find that transitioning to race-neutral equations leads to a 141% increase in the prevalence of non-obstructive ventilatory impairments among Black participants, while prevalence decreases among White participants.

Similarly, Moffet *et al*²⁷ demonstrated that switching from the 2012 to 2022 reference equations significantly affects the interpretation of pulmonary function tests in White and Black individuals. Although the study was conducted at a single centre and compared only two ethnic groups, it underscores the importance of using appropriate reference equations to ensure accurate diagnosis and management, particularly for underrepresented groups²⁸.

Building upon these findings, this study aims to assess the clinical and real-world implications of adopting race-neutral PFT interpretation strategies. Specifically, this research examined how the transition to the GLI 2022 race-neutral reference equations affected PFT interpretation in the three most populous ethnic groups, aged 18–95 years, attending Manchester University Foundation Trust (MFT) lung function clinics during the first six months of 2023. Through this analysis, the study aimed to provide critical insights into the broader clinical consequences of shifting from race-specific to race-neutral reference equations.

Aims: This project aimed to evaluate the impact of transitioning from the GLI 2012 race-specific to the GLI 2022 race-neutral reference equations on PFT interpretations in a local patient sample.

A secondary aim is to stratify the impact of the reference equation change by ethnicity (White, Black, and Other/mixed) and obstruction severity.

Materials and Methods

5,716 individual PFT datasets have been identified using the inclusion/exclusion criteria illustrated in Table 3. PFT data was collected across all MFT sites using a software called Sentriesuite™ (Version v 3.20.5), created by Vyair™.²⁹ All tests were performed and assessed in accordance with ERS/ATS acceptability and repeatability criteria¹.

Table 3: Inclusion/Exclusion criteria

Inclusion criteria
- Aged 18-95 years - Completed spirometry lung function test (acceptable and repeatable FEV₁ and FVC values present) - Test performed between 1st January 2023 – 30th June 2023 - Ethnicity grouped as either Caucasian; Black; or Other/mixed. - Test performed at any Manchester Foundation NHS Trust (MFT) site.
Exclusion criteria
- Multiple datasets from the same individual - Biological Quality control (BioQC) datasets - Ethnicity field not entered into database/not known

Statistical Analysis

Statistical analysis was conducted using Rstudio (version 2024.12.0.467) with R (version 4.4.2). The key parameters for analysis include the comparison between GLI 2012 race-specific and GLI 2022 race-neutral reference equations for the presence of impairment (Obstruction, Restriction or Mixed/Non-specific), specific identification of obstruction, and recognition of restriction.

Lower Limits of Normal (LLN) for Forced Expiratory Volume in one second (FEV₁), Forced Vital Capacity (FVC), and the FEV₁/FVC ratio were calculated using both the GLI 2012 race-specific and GLI 2022 race-neutral equations. Abnormal results were defined as values below the 5th percentile, corresponding to a Z-score less than -1.645, which served as the LLN. This threshold aligns with local department policy and ERS/ATS guidelines¹.

Furthermore, the severity of obstruction was classified into three categories: Mild, Moderate, and Severe. The specific criteria for defining types of lung function impairment and obstruction severity are detailed below in Tables 4–6 and are also taken from the most recent ERS/ATS technical standard¹.

Descriptive statistics were used to evaluate absolute and percentage changes in pulmonary function interpretations across the three different ethnic groups used in this dataset. This analysis was conducted using both the GLI 2012 race-specific and GLI 2022 race-neutral reference equations, providing a comprehensive evaluation of the impact of transitioning to the updated reference standards.



Table 4: Classification of Pulmonary Function Impairment

Category	Criteria	Cut-off (Z-score)
Obstructive	FEV ₁ /FVC ratio	< -1.645 (LLN)
Restrictive *	FVC and FEV ₁ /FVC	FVC < LLN and FEV ₁ /FVC > LLN
Mixed/Non-specific	FVC and FEV ₁ /FVC	Both < LLN

*Suggestive of restrictive lung function, lung volumes measurements required to confirm true restriction.

Table 5: Pulmonary Function Impairment Status

Status	Definition
Impaired	Presence of any obstructive, restrictive, or mixed/non-specific lung function impairment.
Normal	No lung function impairment (all results within normal limits).

Table 6: Severity of Obstruction (Obstructed patients only)

Severity Level	FEV ₁ Z-score Cut-off
Normal	No obstruction present (FEV ₁ /FVC ratio normal)
Mild	FEV ₁ > -2.51
Moderate	-2.50 ≥ FEV ₁ > -4.00
Severe	FEV ₁ < -4.00

To quantify differences in pulmonary function, means, medians, and mean differences in FEV₁ Z-scores were calculated for both reference equations. Bland-Altman plots were used to visualise the mean difference between the two reference equations. Boxplots, incorporating median differences and 1.5 × interquartile range (IQR) whiskers, illustrated the distribution of FEV₁ Z-score differences for both race-specific and race-neutral reference equations.

A summary table was constructed to report the number of patients (N) and percentage change (% Change) in pulmonary function impairment classification among patients with impaired lung function, stratified by ethnicity. This allowed for a direct comparison of impairment prevalence before and after the transition to the GLI 2022 race-neutral reference equations.

Additionally, Sankey diagrams were used to visually represent shifts in obstruction severity across ethnic groups when transitioning from GLI 2012 race-specific to GLI 2022 race-neutral reference equations, providing insight into the

reclassification patterns within each ethnicity group.

Ethics

All data were securely stored on MFT servers in compliance with the Data Protection Act (2018)³⁰ and the current information governance framework³¹. No patient-identifiable information was included in the dataset. The dataset contained only PFT values, along with age, height, weight, sex, and self-reported ethnicity.

Results

PFT datasets from 5,716 patients were analysed, with 4,863 Caucasian (White, 85.0%); 191 Black (3.3%); and 662 Other/mixed (11.6%). Datasets were interpreted using both GLI 2012 race-specific and GLI Global 2022 race-neutral reference equations and interpretations were compared.

The White cohort had median FEV₁ z-scores of -1.04 (IQR: -2.03 to -0.16) for race-specific and -0.74 (IQR: -1.71 to 0.14) for race-neutral. The Black cohort's medians were -0.66 (IQR: -1.79 to 0.02) for race-specific and -1.23 (IQR: -2.30 to -0.56) for race-neutral. The Other/Mixed cohort showed medians of -1.37 (IQR: -2.29 to -0.47) for race-specific and -1.31 (IQR: -2.15 to -0.51) for race-neutral (Figure 1).

The mean difference in FEV₁ Z-scores between race-specific and race-neutral reference equations was -0.31 [LOA: 0.08; -0.71] in the White cohort, 0.53 (LOA: 0.93; 0.13) in the Black cohort, and -0.06 (LOA: 0.36; -0.49) in the Other/Mixed cohort (Figure 2).

In the White cohort, obstruction prevalence increased from 20.7% (n = 1007) to 24.2% (n = 1175) (+3.5%), while restriction prevalence decreased from 15.7% (n = 765) to 11.1% (n = 541) (-4.6%). The overall prevalence of impairment rose slightly from 37.7% (n = 1834) to 39.6% (n = 1924) (+1.9%).

For Black patients, obstruction decreased from 13.1% (n = 25) to 10.9% (n = 21) (-1.2%), whereas restriction increased from 16.8% (n = 32) to 27.7% (n = 53) (+10.9%). The total impairment prevalence also rose from 34.0% (n = 65) to 45.0% (n = 86) (+11.0%). The unexpected shift in obstruction prevalence is likely driven by the reclassification of patients into alternate impairment groups.

In the Other/Mixed cohort, minimal changes were observed. Obstruction decreased from 13.6% (n = 90) to 13.0% (n = 86) (-0.6%), and restriction

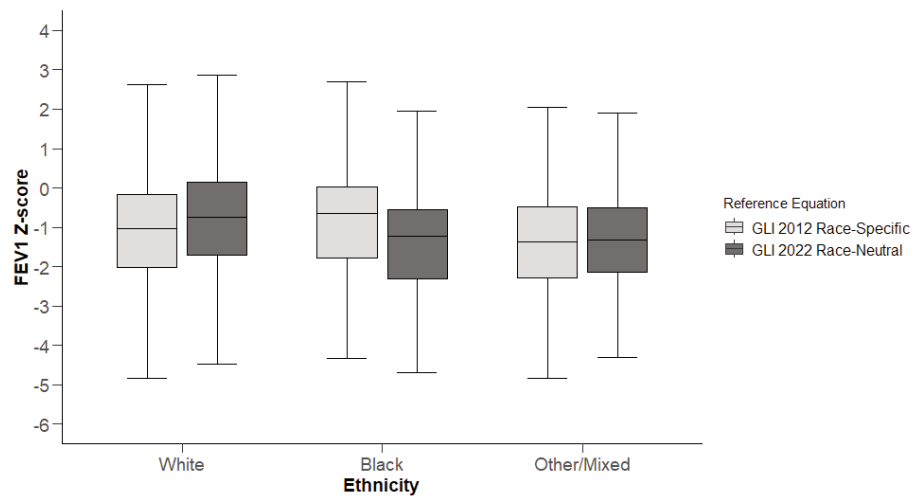


Figure 1: Boxplot of FEV₁ Z-scores using both GLI 2012 race-specific and GLI 2022 race-neutral reference equations, stratified by ethnicity group.

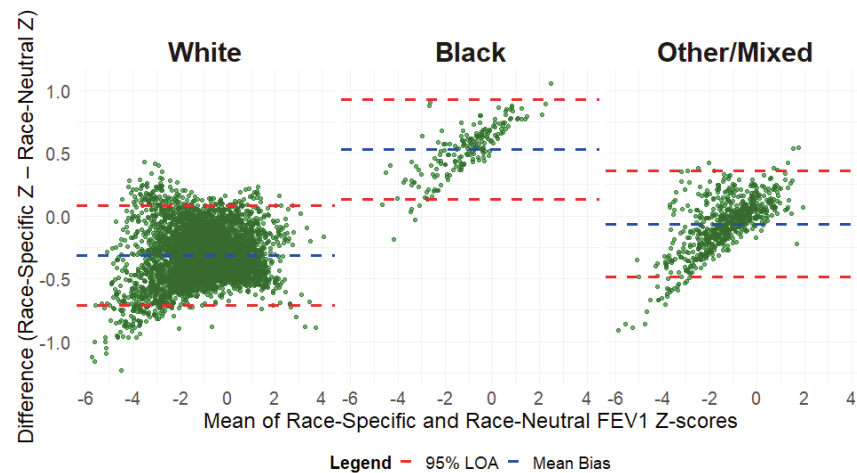


Figure 2: Bland-Altman plots showing differences between race-specific and race-neutral reference equation FEV₁ Z-scores (calculated as Race-Specific Z – Race-Neutral Z) by ethnicity. Horizontal lines indicate the mean bias (blue dashed line) and 95% limits of agreement (red dashed lines). Each point represents a single patient.

declined from 30.8% (n = 204) to 27.6% (n = 183) (-3.2%). The total impairment prevalence remained relatively stable, shifting from 45.6% (n = 302) to 46.3% (n = 306) (+0.7%). These changes are summarised below in Table 7.

Obstruction Severity

In the White cohort (Figure 3), the number of patients classified with mild obstruction increased from 732 to 802 (+9.6%), while moderate obstruction decreased from 243 to 190 (-21.8%). The most significant reduction was observed in severe obstruction, which dropped

from 32 to 15 (-53.1%). Overall, 9.2% of White obstructed patients changed severity.

Among Black patients (Figure 4), the number classified with mild obstruction declined from 21 to 16 (-23.8%), while those in the moderate category increased slightly from 4 to 5 (+25.0%). No patients were classified as severely obstructed under either reference equation. Additionally, four patients were newly categorised as non-specific/mixed obstruction under the race-neutral equations. Overall, 8% of Black obstructed patients changed severity.



Table 7: Prevalence of Obstruction, Restriction, Mixed/Non-Specific, and Impairment

Group	Category	GLI 2012 Race-specific (N, %)	GLI Global 2022 Race-neutral (N, %)	% Change in prevalence
White	Obstruction	1007 (20.7%)	1175 (24.2%)	+3.5%
	Restriction*	765 (15.7%)	541 (11.1%)	-4.6%
	Mixed/Non-Specific	270 (5.6%)	208 (4.3%)	-1.3%
	Impairment**	1834 (37.7%)	1924 (39.6%)	+1.9%
Black	Obstruction	25 (13.1%)	21 (10.9%)	-1.2%
	Restriction*	32 (16.8%)	53 (27.7%)	+10.9%
	Mixed/Non-Specific	8 (4.2%)	12 (6.3%)	+2.1%
	Impairment**	65 (34.0%)	86 (45.0%)	+11.0%
Other/Mixed	Obstruction	90 (13.6%)	86 (13.0%)	-0.6%
	Restriction*	204 (30.8%)	183 (27.6%)	-3.2%
	Mixed/Non-Specific	45 (6.8%)	37 (5.6%)	-1.2%
	Impairment**	302 (45.6%)	306 (46.3%)	+0.7%

* Suggestion of restriction; lung volume measurements required for confirmation.

** Impairment = Obstruction, Restriction, or Mixed/Non-Specific.

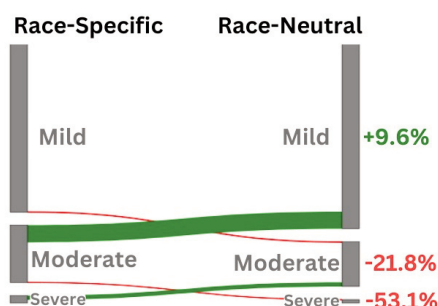


Figure 4: White patients obstruction severity transitions from GLI 2012 race-specific to GLI 2022 race-neutral reference equations.

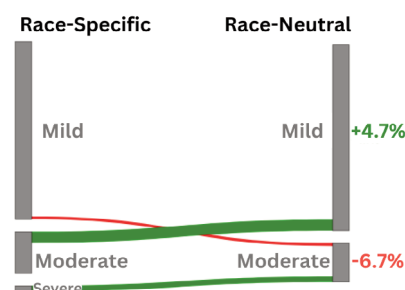


Figure 6: Black patients obstruction severity transitions from GLI 2012 race-specific to GLI 2022 race-neutral reference equations.

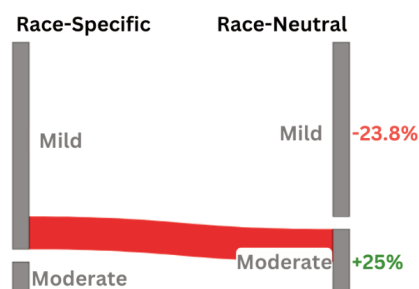


Figure 5: Black patients obstruction severity transitions from GLI 2012 race-specific to GLI 2022 race-neutral reference equations.

For the Other/Mixed cohort (Figure 5), mild obstruction increased slightly from 64 to 67 (+4.7%), while moderate obstruction remained

relatively stable, decreasing slightly from 15 to 14 (-6.7%). Notably, severe obstruction was eliminated, with the number of cases decreasing from 2 to 0 (-100%). Additionally, nine patients previously classified as obstructed were reclassified as normal under the race-neutral equations. Overall, 7.8% of Other/mixed obstructed patients changed severity.

Across all ethnic groups, 9.2% of patients with obstruction experienced a change in severity grading when transitioning from GLI 2012 race-specific to GLI 2022 race-neutral reference equations. In total, 8.1% of the total cohort underwent reclassification; this encompasses changes to either their impairment type or the severity of their obstruction following the adoption of the GLI 2022 equations.



Discussion

This study demonstrated that transitioning to the GLI Global 2022 race-neutral equations resulted in 8.1% (n= 465) of total patients experiencing changes in PFT interpretation, with the most notable impact in the Black cohort, where impairment prevalence increased by 11%.

Larger multicentre studies corroborate with our findings, demonstrating that 7.6% of total patients across five self-reported ethnic groups had altered PFT classifications, with black patients again being the most affected (14.9%)³². When each of the five ethnic groups was equally represented, the overall impact increased to 10.2%, highlighting an interesting and important area for future research within our patient sample.

Given that the “Other/mixed” category is a composite average of the ethnicity-specific reference equations, it is unsurprising that this cohort exhibited only relatively small differences when transitioning to race-neutral equations.

Understanding the historical context of how race became integrated into pulmonary function testing interpretation is important and should be communicated clearly to clinicians and healthcare professionals. Furthermore, increasing education on the non-genetic determinants of pulmonary function, such as socioeconomic status, is crucial, as these factors can contribute to racial disparities in lung growth and functional decline⁹.

While the GLI Global 2022 race-neutral reference equations may demonstrate progress toward reducing these disparities, they are not entirely free from racial and ethnic influences. The GLI authors themselves acknowledge that although the race-neutral approach minimizes these systemic biases, it does not eliminate them¹.

Additionally, no interpretive strategy for PFT results is a meaningful replacement for clinical context. Longitudinal trends of an individual's serial performance remain the single best standard for understanding pulmonary function³³.

Although GLI Global 2022 represents the most progressive step in pulmonary function interpretation to date, further research is needed to fully assess its clinical impact and effectiveness, particularly in more diverse populations. The long-term clinical significance of these changes in PFT interpretation approach remains to be determined.

Clinical implications

Frequent pulmonary function testing as a means

of monitoring patient's lung function is well established and this change in interpretation could have significant clinical implications.

In diseases such as Interstitial Lung Diseases (ILD), PFTs every 3-4 months are recommended, especially in the early stages of diagnosis, in order to closely track progression of the disease which can be rapid and devastating³⁴. Although experienced clinicians may use raw values like FVC to gauge progression, the adoption of race-neutral equations could lead to significant shifts in Z-scores between tests, potentially altering patient treatment pathways.

For instance, in Idiopathic Pulmonary Fibrosis (IPF-ILD), FVC as a percentage of predicted value (FVC%pred) historically guided important decisions on initiating therapies like antifibrotic medications, although recent guidelines have become more flexible in their cutoffs³⁵.

Similarly, in conditions such as Cystic Fibrosis (CF) where PFTs are pivotal in monitoring exacerbations and disease progression³⁶, frequent and accurate assessments are essential. These patients are recommended routine lung function testing at least every 3 months³⁷. Given that CF predominantly manifests with an obstructive lung function pattern, reinterpreting these metrics could have significant implications for this patient population³⁸.

Furthermore, health disparities based on race and ethnicity are well-documented in CF, where minority groups often experience notable delays in care compared to their white counterparts, as well as overall poorer clinical outcomes^{39,40}.

Reference equations are essential not only for disease diagnosis or monitoring, but also for determining eligibility for medical procedures, including transplantation, and even in occupational health screenings. If the adoption of race-neutral equations results in Black patients appearing to have lower lung function while White patients appear to have slightly better lung function, this could have unintended and potentially harmful consequences, such as limiting employment opportunities for non-white populations, thereby exacerbating existing societal disparities²⁷. Conversely, utilising race-neutral equations may have the potential to underdiagnose lung disease in White populations.

Further research is needed to properly quantify the broader societal impact of changing reference equations.



Limitations and areas for future research

There are limitations to this study, it was a single centre service evaluation with a relatively small sample size ($n=5716$), especially in those non-white cohorts (15%). Sample sizes for the other GLI race-specific ethnicity groups (North East Asian, South East Asian) were so small that they could not feasibly be added to the analysis.

The small representation of minority ethnic groups included in this analysis poses challenges in obtaining more robust data on these populations. As a result, the significant interpretation changes observed in this study may underestimate the true impact of this shift. The effect could be even greater if conducted in centres with greater demographic diversity.

Given that the study population was predominantly White (85%), there is a risk that these findings may inadvertently contribute to widening the very disparities that this research aims to address.

Although beyond the scope of this study, future analyses could incorporate stratification by factors such as age, clinical diagnosis, environmental exposures, and socioeconomic status utilising multivariable logistic regression. This approach may reveal additional patterns and provide deeper insights into the implications of changing reference equations. Notably, socioeconomic and environmental factors are believed to play a more significant role in shaping lung function variability within ethnic groups rather than between them. This remains a critically underexplored area in pulmonary function research and represents a possible direction for future research.

Conclusion

The limitations of using race-specific reference equations are clear, and the availability of race-neutral global reference equations strongly supports their implementation across pulmonary function testing centres. The continued use of race in PFT interpretation has the potential to perpetuate systemic biases in healthcare, which can begin to be addressed with the adoption of race-neutral reference equations.

This study evaluated the impact of transitioning from GLI 2012 race-specific to GLI 2022 global race-neutral equations on PFT interpretations. The adoption of GLI 2022 race-neutral equations will have a significant effect on spirometry interpretation.

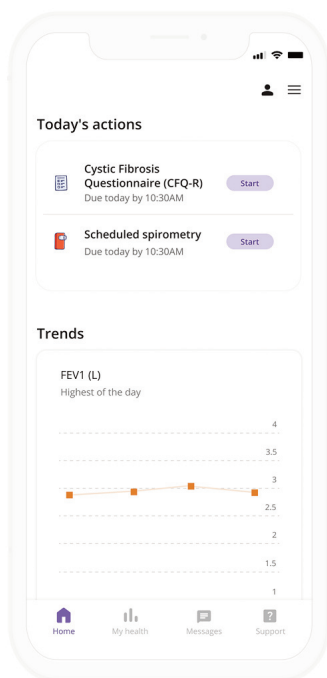
While the shift to race-neutral equations represents progress, further research, especially in non-White cohorts, is needed to fully evaluate its clinical impact.

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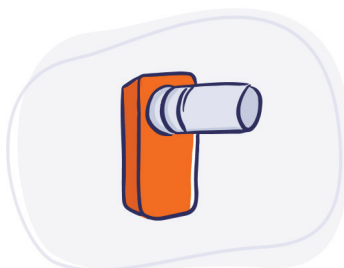
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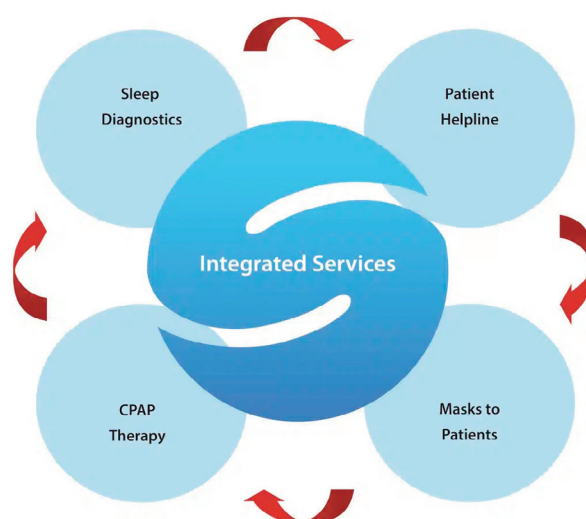
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In memory of Dr Duncan CS Hutchison BA BM BCh FRCP FRSM (1931–2025)

Contributors – Peter Hutchison, Adrian Kendrick

Dr Duncan CS Hutchison passed away on 11 November 2025. He is survived by his son Peter, daughter Celia, daughter-in-law Diana, and grandchildren Miranda and Ash.

Duncan was one of the ARTP's early members back in 1976. He will be remembered for his scientific rigour, gentle kindness, and a wry sense of humour that put patients and colleagues alike at ease.



Duncan in Paris for his 80th birthday

Early education and clinical training

Duncan studied medicine at University College, Oxford, completing an undergraduate degree in Physiology (BA, 1953) and subsequently his BM (1956), before clinical studies at Guy's Hospital Medical School. This grounding—basic science first, clinical application next—shaped the rest of his career.

First steps in lung function—and a lifelong mission

His first post (1958) was as SHO at Joyce Green Hospital, Dartford, where he was entrusted with running a new lung function laboratory under Dr Paul Forgacs. There he learned—meticulously—how lung function tests should and should not be performed. Those lessons became the thread running through decades of work: accurate measurement, careful interpretation, and standards that clinicians could trust, especially for the diagnosis and management of emphysema.



Duncan with Ann in the Pyrenees

While at Joyce Green, Duncan met Ann Stewart, then a junior doctor in Paediatrics who would later become Consultant in Perinatal Medicine at University College Hospital, London, with a distinguished research career in the outcomes of premature infants. They married in 1959 and moved to Edinburgh, where Duncan worked as Research Assistant and then Lecturer in Chest Medicine at the Royal Infirmary, and where their children Peter and Celia were born.

King's College Hospital and seminal work on emphysema

In 1968 the family returned to London, where Duncan became Lecturer (later Senior Lecturer and Consultant) in the Chest Unit at King's College Hospital and Medical School. There, his research focus on emphysema deepened. Shortly after arriving, he began a long collaboration with Peter Cook (a colleague of Ann's), exploring hereditary α_1 -antitrypsin deficiency (AATD). Their work produced one of the early landmark papers linking AATD to pulmonary emphysema—Hutchison et al., *BMJ* 1971;1:689–694—drawing on data from Duncan's clinics. He went on to contribute to larger studies that clarified the interplay between phenotype, smoking, and susceptibility to emphysema (e.g., Tobin et al., *Br J Dis Chest* 1983; Hutchison et al., *Br J Dis Chest* 1983;77: 28–34). He would joke at home that a major part of his job was “telling patients to stop smoking”—with, he admitted, mixed success.



Gene geography and the ‘isogenes’ map

In the 1990s Duncan compiled data from 98 population surveys across Europe, plotting lines of equal gene frequency (“isogenes”) for AATD in a novel, weather-map-like visualisation. His seminal 1998 paper (*Respir Med* 1998;92:367–77) highlighted the north-west European seaboard as a region of relatively high frequency of the type Z variant, positing an origin in southern Scandinavia and spread with Viking colonisation (9th–11th centuries CE)—a striking, integrative piece of clinical population genetics that remains widely cited.

ARTP, Breath, Standards, and the craft of testing

(written by Dr. Adrian Kendrick)

Duncan was one of the founding members of the ARTP. He, along with MF Clay, produced the ARTP “Newsletter”, and in January 1977 (Issue 3) published a report on the second AGM held in freezing weather in Penarth—one or two names from the past mentioned!

Within 1977, the newsletter became *Breath*, and as noted by the editor (Hutch), “We decided that our Association Newsletter ought to have a rather more professional look... and that the Newsletter had acquired a new title – *Breath*.” By Issue 9 (February 1980), the journal had become glossy, and from Issue 10 the journal title changed colour with each edition, with Jane Jones (London Chest) becoming its Assistant Editor. *Breath* was produced three times each year.

In 1986, Jane stepped down from the Assistant Editor role. From 1986 until 1993, I had the great pleasure of working with Hutch producing *Breath*. This was great fun, and on three Sundays each year I visited Hutch’s home in

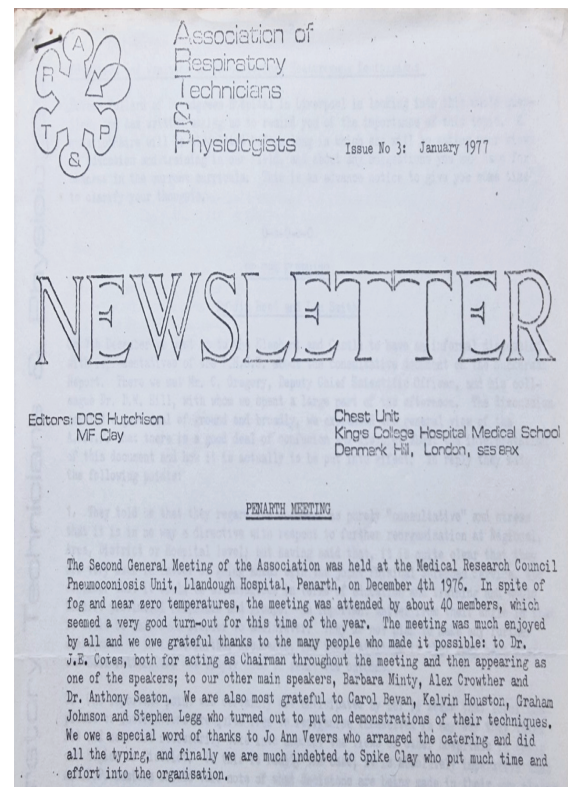
London where we literally cut-and-pasted the text into columns for the printer to typeset—not a computer in sight! Once we had completed this task, we sat down to a traditional Sunday roast prepared by his wonderful wife Ann. After this feast, I wended my way back to Bristol after a totally enjoyable day with both Hutch and Ann.

In 1993, *Breath* evolved into *INSPIRE* with a new editorial team replacing Hutch and myself.

ARTP Guidelines and Practical Handbook

In 1993 Hutch chaired an ARTP committee to draft guidelines for lung function testing and methodology. We met at the then BTS headquarters next to the Royal College of Physicians and worked hard to produce the guidelines published in *Respiratory Medicine* in 1994. The guidelines group were precise and pedantic, but always chaired with great humour.

Hutch and colleagues argued that, particularly in emphysema, relaxed capacities (rather than strictly forced manoeuvres) could be more reliable for diagnosis and tracking response to treatment. Noticing in 2023 that aspects of these recommendations were drifting from practice, he wrote for *INSPIRE* (2024) to restate the physiological rationale—an exemplar of his 65-year commitment to measurement done properly.





Following the guidelines, Hutch and many of those involved produced the first edition of *The Practical Handbook* in 1999, edited by Sue Hill and Clare Newall. His contributions to “Laboratory Practice” (Chapter 1) and especially as author of Chapter 11 (“Interpretation of Lung Function Tests”, with illustrative cases) were significant.

Tuberculosis service and advocacy

From the late 1990s, Duncan established the TB clinic at King’s College Hospital, later serving as Senior Clinical Specialist. He authored local TB management guidelines, sat on the LSL Health Authority “TB Forum” (later SE Sector Working Party), delivered study days for refugees and asylum seekers (including at Basle Court Refugee Hostel), contributed to the *Refugee Council News/letter*, and helped develop patient education leaflets and posters.

He stepped down from his King’s role to care for Ann in her final years until she sadly passed in 2004. He later took a part-time post in the national TB test laboratory, advising clinicians on drug-resistant TB and complex cases with comorbidities—work he found both challenging and profoundly meaningful.

The person behind the achievements

For all his scholarly output, Duncan will be most keenly remembered for his patience with trainees, generosity with his time, and unfailing kindness to patients and families. He delighted in clear graphs, carefully calibrated kit, and a well-placed joke. His legacy—scientific, clinical, and human—lives on in the standards we use, the patients we serve, and the colleagues he mentored.

He will be greatly missed by family, friends, and the respiratory community.

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¹ Database analysis; Pépin JL, Bailly S, Rinder P et al. J Clin Med. 2021;10(5):936. ² Strollo et al. NEJM 2015. ³ Woodson BT et al, Otolaryngol Head Neck Surg. 2016. ⁴ Woodson et al, OtoHNS 2018. ⁵ Woodson, BT, Strohl, K P, Soose, R J et al. Upper Airway Stimulation for Obstructive Sleep Apnea: 5-Year Outcomes. Otolaryngology–Head and Neck Surgery 2018; 159(1):194–202. ⁶ Kim et al, OtoHNS 2023. ⁷ Suurna et al. Laryngoscope 2021.

* 8670 total patients: 8637 with Inspire and 33 with other devices. 80% met the Sher criteria (AHI reduction by 50 % and <20 events per hour) within 12 months (95% CI 79.14% to 80.83%). In addition, approximately 82% of patients achieved an AHI <15 at 12 months (95% CI 81.18% to 82.79%).

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Improving Diagnostic Pathways for Unexplained Breathlessness: a Clinical Scientist-led one-stop service evaluation in a Community Diagnostic Centre

Mr Andrew Pritchard, Miss Megan Beacham, Dr Helen Ward

Royal Wolverhampton NHS Trust, Wolverhampton, UK

Introduction

Breathlessness is a common and distressing symptom encountered across healthcare settings and is associated with substantial morbidity and healthcare utilisation¹. Patients presenting with chronic dyspnoea frequently experience reduced functional capacity, impaired quality of life, and increased healthcare contact. The symptom may arise from a wide range of respiratory, cardiovascular, metabolic, and psychological conditions, and the subjective experience of breathlessness often reflects complex interactions between physiological impairment and perceptual factors. As a result, diagnostic evaluation of chronic breathlessness remains challenging in routine clinical practice².

The clinical burden associated with chronic breathlessness has been increasingly recognised in recent years. Persistent dyspnoea is associated with significant limitations in daily activities and can be a major driver of healthcare utilisation across both primary and secondary care settings¹. The concept of chronic breathlessness syndrome has been proposed to emphasise the persistent and disabling nature of the symptom when it continues despite optimal management of the underlying disease³. These observations highlight the importance of efficient diagnostic pathways that enable the timely identification and management of underlying causes.

Despite its clinical importance, the investigation of chronic breathlessness is frequently fragmented. Traditional diagnostic pathways often involve sequential referrals between specialities, with patients attending multiple outpatient appointments and undergoing investigations at different stages of the pathway. This approach can lead to prolonged diagnostic journeys, particularly when initial investigations fail to identify a clear underlying cause. Patients

with unexplained dyspnoea may therefore experience extended periods of uncertainty before receiving a diagnosis. This is consistent with evidence from primary care demonstrating that patients presenting with breathlessness frequently experience delays in diagnosis and repeated healthcare encounters prior to diagnostic clarification⁴.

In practice, investigation of breathlessness frequently involves a sequence of speciality-based referrals and diagnostic tests arranged over multiple appointments. Patients may initially undergo investigation in primary care before referral to respiratory, cardiology, or other specialist services, depending on the suspected cause of symptoms. Diagnostic investigations such as pulmonary function testing, cardiac imaging, or exercise testing are often performed at different stages of this pathway and interpreted within separate clinical encounters. This sequential approach can result in repeated outpatient visits and prolonged diagnostic timelines, particularly when initial investigations fail to identify a single underlying cause⁵. For patients with multifactorial breathlessness, diagnostic resolution may therefore require several months of investigation before a clear explanation for symptoms is established³.

The heterogeneous causes of breathlessness contributes to this complexity. Respiratory disease, cardiac dysfunction, deconditioning, dysfunctional breathing, and psychosocial factors may all contribute to symptom burden. In many cases, more than one mechanism may be present simultaneously⁶. Conventional speciality-based outpatient pathways may struggle to address these interacting contributors efficiently, particularly when investigation and interpretation are distributed across multiple clinical services².



In response to these challenges, several models of integrated breathlessness assessment have been proposed. Multidisciplinary breathlessness services have been described in a number of healthcare systems and aim to provide coordinated evaluation of patients with complex dyspnoea. These services typically combine clinical assessment with targeted physiological investigation to reduce fragmentation in diagnostic pathways. Evidence from such services suggests that integrated assessment models may improve patient experience and facilitate earlier diagnostic clarification^{3,7-9}.

Within the United Kingdom, national policy initiatives have sought to support more efficient diagnostic pathways. NHS England has introduced an adult breathlessness diagnostic pathway intended to promote earlier identification of underlying pathology and to standardise the investigation of patients presenting with unexplained dyspnoea¹⁰. The pathway emphasises structured pre-referral assessment in primary care and encourages integrated diagnostic investigation within Community Diagnostic Centres (CDCs). These centres have been developed to expand access to diagnostic testing and to provide protected capacity for elective investigation outside acute hospital environments¹¹.

The establishment of CDCs also creates opportunities to explore innovative workforce models within diagnostic services. Clinical Scientists specialising in respiratory and sleep physiology possess extensive expertise in the acquisition and interpretation of physiological diagnostic tests, including spirometry, lung volume measurement, gas transfer testing, and cardiopulmonary exercise testing. Increasingly, advanced practice roles have enabled healthcare scientists to undertake patient-facing clinical responsibilities within defined pathways, including diagnostic assessment and interpretation of complex physiological data^{12,13}.

Recent literature has highlighted the evolving role of healthcare scientists in delivering patient-centred diagnostic services. Expanding clinical responsibilities for healthcare scientists have been described across several specialities, reflecting both the increasing complexity of diagnostic technologies and the need for innovative workforce solutions to address growing demand for diagnostic investigations¹⁴. These developments suggest that advanced healthcare scientists may play an important role

in supporting integrated diagnostic pathways within modern healthcare systems. Contemporary approaches to the assessment of chronic dyspnoea increasingly emphasise structured diagnostic pathways that integrate clinical assessment with targeted investigation to improve diagnostic efficiency¹⁵.

Against this background, a Clinical Scientist-led one-stop diagnostic clinic for patients with chronic unexplained breathlessness was established within a CDC in the Black Country. The clinic was designed to provide an integrated diagnostic assessment within a single visit, combining structured clinical history with targeted physiological investigation. The pathway aimed to reduce diagnostic delays, improve service efficiency, and provide clear diagnostic conclusions where possible.

The present study aimed to evaluate the performance of this Clinical Scientist-led diagnostic pathway using routinely collected clinical data. The evaluation focused on service activity, waiting times, diagnostic outcomes, and patient disposition following assessment within the pathway. This evaluation also provides an example of how advanced healthcare scientists may contribute to emerging diagnostic service models within CDCs.

Methods

Study design

This study represents a retrospective service evaluation of a Clinical Scientist-led diagnostic pathway for patients presenting with chronic unexplained breathlessness. The evaluation utilised routinely collected clinical data from patients referred into the pathway between the 1st November 2023 and 31st March 2025. The purpose of the evaluation was to describe the activity and outcomes of the pathway and to assess its impact on service efficiency compared with conventional respiratory outpatient services within the same organisation. Preliminary findings from this pathway have previously been presented in abstract form¹⁶. The study was registered as a service evaluation with Royal Wolverhampton NHS trust.

Service setting

The breathlessness clinic was delivered within a CDC associated with a large NHS Trust in the West Midlands, United Kingdom. CDCs have



been developed within the National Health Service to expand access to diagnostic investigations and to support elective diagnostic pathways outside acute hospital environments¹¹. The centre provides a range of diagnostic services, including respiratory physiology testing, imaging, and cardiovascular investigations. The breathlessness pathway was designed as a one-stop diagnostic clinic in which patients underwent structured clinical assessment and targeted physiological investigation during a single appointment. The pathway was led by a Clinical Scientist specialising in respiratory and sleep physiology, working within an established multidisciplinary diagnostic service.

Referral criteria

Patients were referred from primary care for investigation of chronic breathlessness, where the underlying cause remained unclear following initial clinical assessment. Referrers were required to complete a defined pre-referral investigation bundle before referral to the clinic. This bundle was intended to ensure that common causes of breathlessness had been considered and that baseline investigations had been completed before entry into the diagnostic pathway. The pre-referral investigations included chest radiography, electrocardiography, routine blood tests and measurement of NT-proBNP.

Patients were typically referred when breathlessness had been present for longer than

eight weeks and remained unexplained following initial investigation. Patients with a known diagnosis of asthma or chronic obstructive pulmonary disease were generally not referred unless diagnostic uncertainty persisted. Individuals with red flag symptoms suggestive of malignancy, acute cardiorespiratory disease, or other urgent pathology were excluded from the pathway and directed to alternative clinical services.

All referrals were reviewed by a Clinical Scientist before booking to confirm suitability for the pathway. The referral framework for the pathway, including required pre-referral investigations, eligibility criteria and exclusion criteria, is summarised in Figure 1.

Patients attended a single diagnostic appointment within the CDC. During this appointment, a structured clinical history was obtained, including assessment of symptom onset, severity, functional limitation, and relevant medical history. The operational workflow of the pathway is illustrated in Figure 2. Physiological investigations were performed during the same visit. These typically included spirometry and gas transfer testing, with additional investigations undertaken where clinically indicated. The selection of investigations was guided by the clinical history and existing referral information.

Diagnostic pathway

Following completion of the diagnostic investigations, results were reviewed by the

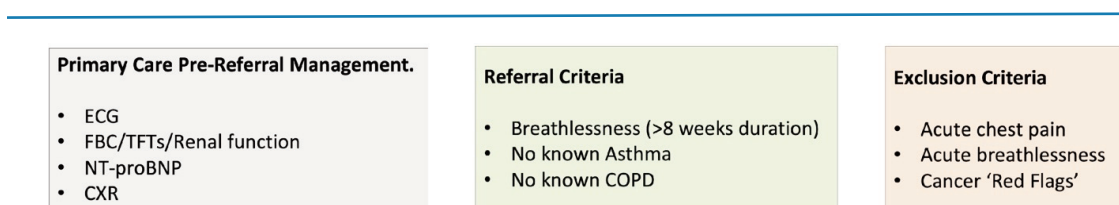


Figure 1. Referral framework for the Clinical Scientist-led breathlessness diagnostic pathway.

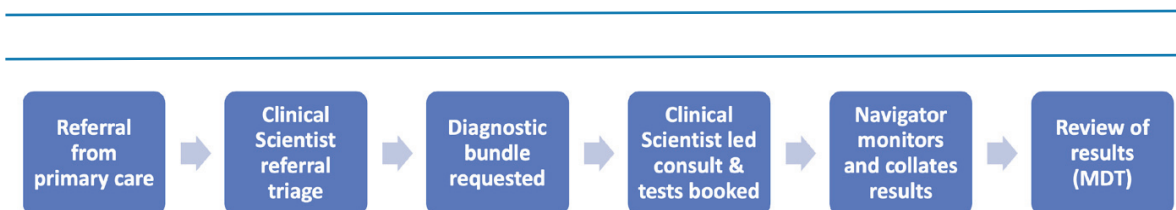


Figure 2. Clinical workflow of the Clinical Scientist-led breathlessness diagnostic pathway.

Patients were referred from primary care and underwent triage by a Clinical Scientist to confirm suitability for the pathway. A targeted diagnostic bundle was then requested before a one-stop clinical consultation and physiological assessment. Diagnostic results were subsequently reviewed within a multidisciplinary framework, where required, before outcomes were communicated to the referring clinician.

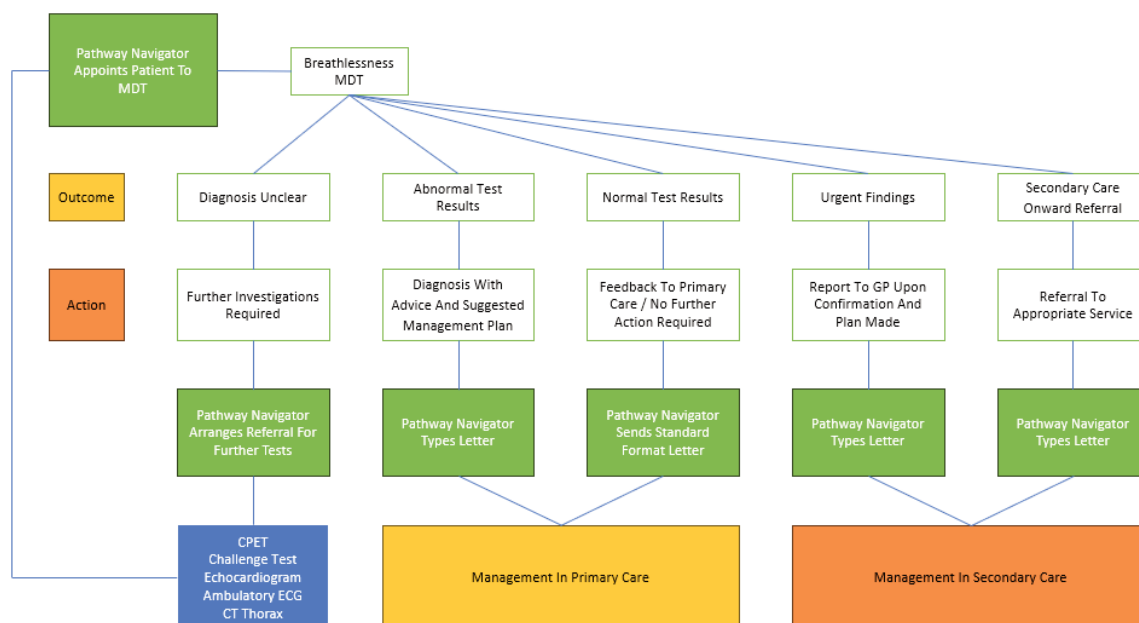


Figure 3. Multidisciplinary decision framework for the breathlessness diagnostic pathway.

Following completion of the diagnostic consultation and physiological investigations, patient cases were reviewed within a multidisciplinary team (MDT) framework where appropriate. Diagnostic findings informed a structured set of potential outcomes, including clarification of diagnosis with management advice, discharge to primary care following normal investigations, urgent clinical escalation, or onward referral for specialist assessment. A pathway navigator coordinated further investigations, documentation and communication with referring clinicians.

Clinical Scientist and considered within a multidisciplinary framework where appropriate. A diagnostic conclusion was reached where possible and communicated to the referring clinician. Patients were either discharged to primary care with management recommendations or referred onward for specialist review when further investigation or treatment was required. The potential diagnostic outcomes and subsequent management pathways following MDT review are illustrated in Figure 3.

Outcome measures

The evaluation focused on service-level outcomes, including referral-to-appointment waiting time, referral-to-discharge time, diagnostic outcomes following assessment, and patient disposition after completion of the pathway. Waiting time metrics were compared with those observed within conventional general respiratory outpatient clinics within the same NHS Trust during the same time period. Comparator data were extracted from the Trust patient administration system and summarised using median waiting times.

Data collection and analysis

Clinical and service data were recorded prospectively within a local clinical database as part of routine service delivery. Data were subsequently extracted for analysis following completion of the evaluation period. Continuous variables were summarised using means and standard deviations where appropriate. Categorical variables were expressed as proportions of the total cohort. Statistical analysis was descriptive in nature, and no inferential statistical testing was performed. Data management and analysis were undertaken using Microsoft Excel.

Governance

The evaluation was conducted as a service evaluation using anonymised routinely collected clinical data. The work was undertaken to assess the performance of a newly implemented diagnostic pathway and to inform service development. As no research intervention was undertaken and data were analysed in anonymised form, formal research ethics approval was not required. Individual patient consent was not required for inclusion in the evaluation.



Results

Patient population

Between 1st November 2023 and 31st March 2025, a total of 97 patients were referred to the Clinical Scientist-led breathlessness diagnostic pathway. Patients were referred from primary care for investigation of persistent breathlessness, where the underlying cause remained unclear following initial assessment and investigation. The mean duration of breathlessness before referral was 47.5 weeks, indicating that many patients had experienced symptoms for prolonged periods before entering the diagnostic pathway. Baseline demographic and clinical characteristics of the cohort are summarised in Table 1.

Table 1. Baseline characteristics of patients referred to the Clinical Scientist-led breathlessness pathway.

Characteristic	Value
Total referrals (Nov 2023 – Mar 2025)	97
Discharged to primary care	69% (n=67)
Mean age (years)	59.9 (SD 16.9)
Female	57% (n=55)
Mean duration of breathlessness (weeks)	47.5 (SD 52.0)
MRC dyspnoea score ≤ 3	74% (n=72)

Waiting time outcomes

The breathlessness diagnostic pathway demonstrated shorter waiting times compared with conventional general respiratory outpatient services within the same organisation. The median referral-to-appointment time within the breathlessness clinic was 34 days, compared with 71 days for patients referred to general respiratory outpatient clinics. Similarly, the median referral-to-discharge time was 157 days for patients managed within the breathlessness pathway, compared with 188 days for patients managed through conventional respiratory outpatient pathways (Figure 4).

These findings indicate that patients entering the breathlessness pathway experienced shorter diagnostic timelines compared with those managed through conventional outpatient services.

Diagnostic outcomes

Respiratory disease represented the most common diagnostic category identified within the cohort. A primary respiratory diagnosis was established in 57% of patients (n=55) following

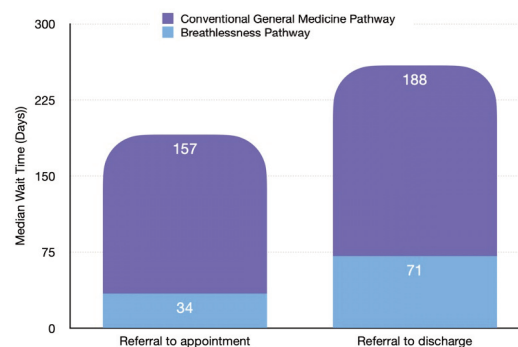


Figure 4. Comparison of waiting times between the breathlessness diagnostic pathway and conventional respiratory outpatient services. Median waiting times for referral-to-appointment and referral-to-discharge were shorter for patients managed within the Clinical Scientist-led breathlessness pathway compared with conventional respiratory outpatient pathways within the same NHS Trust.

assessment within the pathway. Functional or psychosocial contributors to breathlessness were identified in 24% of patients (n=23). These cases typically involved conditions such as breathing pattern disorder or anxiety-related symptoms contributing to the patient's presentation. A small proportion of patients required onward referral for further specialist investigation or management. Six per cent of patients (n=6) were referred onward following completion of the diagnostic assessment (Figure 5). Respiratory conditions, therefore, accounted for the majority of diagnoses identified within the pathway, although a substantial minority of patients had non-respiratory or multifactorial contributors to breathlessness.

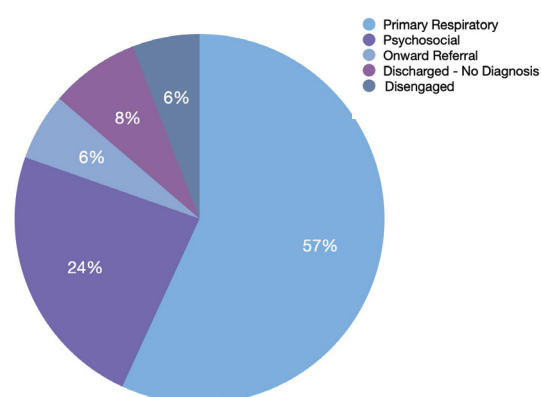


Figure 5. Diagnostic outcomes following assessment in the Clinical Scientist-led breathlessness pathway.



Patient destination

Most patients were discharged back to primary care following completion of the diagnostic pathway. Overall, 69% of patients ($n = 67$) were discharged to their general practitioner with diagnostic conclusions and management recommendations. A further 8% of patients ($n=8$) completed the diagnostic pathway without a definitive diagnosis being established but were discharged with advice for ongoing management in primary care. A small number of patients ($n=6$) disengaged from the pathway before completion of the diagnostic process.

Discussion

Principal findings

This service evaluation describes the implementation of a Clinical Scientist-led one-stop diagnostic clinic for patients presenting with chronic unexplained breathlessness within a CDC. The pathway was associated with shorter referral-to-appointment waiting times compared with conventional respiratory outpatient services within the same organisation. Most patients were discharged to primary care following diagnostic assessment, and respiratory disease accounted for the majority of diagnoses identified within the cohort. Functional or psychosocial contributors to breathlessness were also identified in a substantial proportion of patients.

These findings suggest that a structured one-stop diagnostic pathway can streamline the investigation of chronic breathlessness and allow diagnostic clarification to be achieved efficiently for many patients within a single service encounter. Such models may become increasingly important as CDCs expand across the NHS, and demand for diagnostic assessment of common symptoms continues to increase.

Interpretation of the findings

Several factors may explain the observed performance of the pathway. Traditional outpatient investigation pathways for breathlessness are frequently fragmented, with patients undergoing sequential clinical assessments and investigations over multiple appointments. This approach can lead to delays while investigations are arranged, and results interpreted across different services. By integrating clinical assessment and physiological testing within a single diagnostic encounter, the one-stop clinic reduces the need for repeated

appointments and allows a diagnostic conclusion to be reached more rapidly.

In addition to reducing the number of appointments required to complete the diagnostic process, integrated diagnostic encounters may also facilitate more effective interpretation of physiological investigations. Physiological tests such as spirometry and gas transfer measurement are often most informative when interpreted in the context of the patient's clinical history and symptom pattern. Conducting these investigations during the same consultation in which the clinical history is obtained allows the diagnostic findings to be interpreted immediately within the clinical context. This approach may reduce the risk of inconclusive diagnostic pathways that can occur when investigations and clinical review are separated across multiple appointments. Integrated assessment models may therefore support earlier diagnostic closure and allow patients to receive clearer explanations for their symptoms within a shorter timeframe, which has been highlighted as an important component of breathlessness service design^{3,8,9}.

The use of structured referral criteria and pre-referral investigation also contributed to pathway efficiency. Requiring primary care referrers to complete a defined investigation bundle ensured that baseline investigations had already been undertaken before the patient entered the pathway. This approach reduced duplication of testing and allowed the diagnostic consultation to focus on targeted physiological assessment and interpretation.

The findings also highlight the diagnostic complexity of chronic breathlessness. While respiratory disease represented the most common diagnostic category, a substantial proportion of patients were found to have functional or psychosocial contributors to their symptoms. These findings are consistent with previous studies demonstrating that chronic breathlessness often reflects multiple interacting physiological and perceptual mechanisms^{2,3,17,18}.

Breathing pattern disorder represents a recognised but frequently underdiagnosed contributor to chronic breathlessness, particularly in patients with otherwise normal physiological investigations. Recent work has emphasised the importance of structured clinical assessment in distinguishing abnormal breathing patterns from primary cardiorespiratory pathology and in recognising that these mechanisms may coexist with other physiological abnormalities^{17,18}.



The identification of these contributors within the present pathway supports the value of integrated diagnostic assessment in patients whose symptoms may not be adequately explained by conventional disease-based models. Diagnostic pathways that integrate clinical assessment with physiological investigation may therefore be particularly valuable for patients whose symptoms cannot be explained by a single disease process.

Comparison with previous literature

Previous studies have highlighted the challenges associated with investigating chronic breathlessness within traditional speciality-based outpatient models. Sequential referral pathways may lead to prolonged diagnostic journeys and delayed treatment, particularly for patients with complex or multifactorial symptoms⁵. Integrated breathlessness services have therefore been proposed as a means of improving diagnostic efficiency and patient experience.

Multidisciplinary breathlessness services described in the literature typically combine clinical assessment with coordinated diagnostic investigation and symptom management^{3,8}. These services have demonstrated benefits in terms of symptom control and patient experience, particularly for patients with advanced disease. The pathway described in the present study differs from some previously reported models in that it focuses primarily on diagnostic assessment within a CDC rather than long-term multidisciplinary management. Nevertheless, the findings support the broader principle that integrated diagnostic pathways may improve the investigation of chronic breathlessness.

Role of the healthcare science workforce

The pathway evaluated in this study was delivered by a Clinical Scientist specialising in respiratory physiology, reflecting the expanding role of healthcare scientists in patient-facing diagnostic services. Respiratory healthcare scientists possess extensive expertise in the acquisition and interpretation of physiological investigations, including spirometry, gas transfer testing and cardiopulmonary exercise testing. These diagnostic skills are central to the investigation of patients presenting with unexplained breathlessness.

Recent literature has highlighted the evolving role of healthcare scientists within modern healthcare systems, with advanced practice roles

increasingly involving direct patient assessment and diagnostic interpretation^{12,13}. Such roles have developed in response to increasing demand for diagnostic services and the growing complexity of diagnostic technologies. The present evaluation provides a practical example of how advanced healthcare scientists can contribute to innovative diagnostic service models within CDCs.

Although a formal economic evaluation was not undertaken as part of this study, the workforce model used within the pathway may offer potential efficiency advantages compared with traditional physician-led outpatient models. Further work will be required to explore the cost-effectiveness of Clinical Scientist-led diagnostic services.

The findings also highlight the diagnostic complexity of chronic breathlessness. While respiratory disease represented the most common diagnostic category, a substantial proportion of patients were found to have functional or psychosocial contributors to their symptoms. These findings are consistent with previous studies demonstrating that chronic breathlessness often reflects multiple interacting physiological and perceptual mechanisms^{2,3,17,18}.

Limitations

Several limitations should be acknowledged when interpreting the findings of this evaluation. First, the study represents a descriptive service evaluation conducted within a single centre. As such, the findings may not be directly generalisable to other healthcare settings where referral patterns, workforce structures, or diagnostic resources differ. Second, the evaluation focused on service outcomes rather than clinical outcomes. Diagnostic accuracy and long-term patient outcomes were not assessed, and the study did not include patient-reported outcome measures. These factors limit the ability to evaluate the broader clinical impact of the pathway. Third, the analysis did not include a formal economic evaluation. While the pathway may offer potential efficiency benefits through streamlined investigation and workforce configuration, further work is required to quantify these potential advantages. Finally, a small proportion of patients disengaged from the pathway before completion of the diagnostic process. The reasons for disengagement were not explored within the present evaluation.

Patient-reported outcome measures were not collected as part of the service evaluation, and



therefore, the impact of the pathway on symptom burden or patient experience could not be formally assessed. Previous studies of breathlessness services have emphasised the importance of incorporating patient-reported outcome measures when evaluating interventions aimed at improving symptom management and diagnostic pathways³. Future evaluations of similar diagnostic services may therefore benefit from incorporating validated patient-reported outcome measures to better understand the clinical impact of integrated breathlessness assessment pathways. Furthermore, while the pathway demonstrated shorter diagnostic timelines compared with conventional outpatient services, formal health economic analysis was not undertaken, and further work will be required to determine the cost-effectiveness of this service model.

Future directions

Future research should examine the broader clinical and economic impact of Clinical Scientist-led diagnostic pathways for chronic breathlessness. Prospective studies could incorporate patient-reported outcome measures, diagnostic accuracy assessments and health economic analysis to evaluate the effectiveness of such services more comprehensively. Further evaluation across multiple diagnostic centres would also help determine whether the pathway model described in this study can be successfully replicated in other healthcare settings¹⁹. Recent calls for global breathlessness research highlight the need to address unexplored questions and interdisciplinary links to improve recognition and management worldwide.

Conclusion

This service evaluation demonstrates that a Clinical Scientist-led one-stop clinic for patients with chronic unexplained breathlessness can streamline diagnostic pathways and reduce waiting times compared with conventional outpatient models. The majority of patients were discharged to primary care following diagnostic assessment, suggesting that integrated diagnostic pathways may help resolve diagnostic uncertainty efficiently for many patients. These findings illustrate how advanced healthcare scientists can contribute to patient-facing diagnostic pathways and demonstrate the potential of CDCs to support innovative workforce models for the investigation of chronic breathlessness.

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Lab in the Limelight

Joe Madge

Lead Respiratory Physiologist

Paediatric Respiratory and Sleep Physiology Leicester Children's Hospital, University Hospitals of Leicester Trust



History and overview of the department

The Paediatric Respiratory Physiology Laboratory at Leicester Children's Hospital traces its origins back 45 years to the appointment of Professor Hamish Simpson as Professor of Child Health at the University of Leicester. With a special interest in respiratory paediatrics, Professor Simpson secured funding for a new respiratory laboratory at Leicester Royal Infirmary. Dr Caroline Beardsmore was appointed to lead the lab in 1983, remaining at the helm until her retirement in 2022.

In its early years, the laboratory, managed by the University of Leicester, focused on lung mechanics; it was equipped with peak flow meters, a wet spirometer and whole-body plethysmographs, for both children and infants. Like many laboratories of the time, equipment was often built or adapted in-house, and data were analysed manually. Leicester became one of only three UK centres undertaking infant lung function studies, contributing significantly to understanding early lung growth and development. Research was central to the lab's identity; clinical research fellows trained in lung function techniques while undertaking innovative projects. Clinical assessments were requested by respiratory clinics and wards, with measurements and reporting carried out by Caroline or one of the technical staff members.



Dr Caroline Beardsmore

Professor Simpson had a major interest in Sudden Infant Death Syndrome (then known as Cot Death). An infant sleep laboratory was established where sleep stage could be monitored alongside gas concentrations at the nose, by means of a mass spectrometer. The range of equipment available gradually increased; looking back it seems incredible that the arrival of a pulse oximeter was met with great excitement!



Following Professor Simpson's retirement, Professor Mike Silverman continued to build the lab's research profile. Alongside various laboratory studies came the development of the Leicester Cohorts: wide-reaching epidemiological studies of thousands of children (the earliest had started under Professor Simpson). Detailed knowledge of respiratory history, collected from birth rather than retrospectively, provided an invaluable resource to investigate contributing factors to wheeze and asthma and better define various phenotypes. Leicester has an on-going collaboration with Swiss scientists and clinicians.



*Dr Caroline Beardsmore and Dr Erol Gaillard
(Current Clinical lead for Paediatric Respiratory Medicine)*

In 1990-1991 the NHS underwent a major reorganisation with the establishment of NHS trusts and this led to a clearer differentiation between the University and the NHS. With rapid advances in technology and the arrival of portable electronic spirometers, it became the norm for spirometry to be performed for each child while in clinic. Initially these measurements were made by respiratory nurses. In the early 2000's, as the paediatric respiratory medicine service expanded, an agreement was made with the adult respiratory physiology unit to provide a respiratory physiologist to support the paediatric service. This was to meet the growing demand for respiratory and sleep diagnostic requests.

Gradually, the service continued to expand and with the appointment of additional staff, became fully independent in 2022. Today the service provides a wide range of routine and complex respiratory and sleep investigations, including: spirometry +/- bronchodilator response, full pulmonary function testing with plethysmography and MBWN2 (for measuring LCI), bronchial challenge testing, CPET, overnight oximetry, transcutaneous CO₂ monitoring, actigraphy and limited channel sleep studies. The service also supports the sleep and ventilation services, providing physiologist-led CPAP clinics and acute NIV ward rounds.

The Team

Over the past five years, the Paediatric Respiratory Physiology team has undergone substantial growth and transformation. In 2019, the service comprised two physiologists delivering a broad range of respiratory and sleep diagnostics, alongside supporting CPAP and LTV provision. The team now consists of eight dedicated clinical staff members, supported by two highly valued administrative colleagues.

Prakash Patel has been a part of the Paediatric Respiratory Physiology team for more than 20 years and has seen considerable service evolution during this time. When he first started he was the only full time clinical member of the team and was seen to juggle all elements of the service, including sleep analysis, ventilation, respiratory clinics and specialised testing.

We have two members of the team currently undertaking their degree apprenticeships at Sheffield Hallam University. Gemma Vissani, who joined the team four years ago as an Assistant Physiologist, commenced her degree apprenticeship this year. Sneha George joined the team last year and is in the final year of her degree apprenticeship.



Current team (back left to right; Prakash, Tatiana, Sneha, Sandra, Natalie, Pat, Joey, Joe. Front left to right Gemma, Charlotte).

Charlotte Simpson joined the team two years ago having completed her MSc in Clinical Exercise Physiology. As a sports enthusiast, Charlotte has a keen interest in paediatric exercise testing and has twice presented cases at the ARTP Paediatric Exercise Testing Forum.

We have recently welcomed two new team members. Tatiana Heleno has joined us from Portugal having completed her undergraduate degree in Clinical Physiology. Tatiana has a particular interest in paediatric sleep. Sandra Rupparth is new



to respiratory physiology and joined the team at the end of 2025. She will be working towards her ARTP Paediatric Spirometry Certificate in the coming months.

Pat and Joey are our two administrative colleagues, providing dedicated support to the respiratory and sleep diagnostics services respectively, consistently going above and beyond to ensure the smooth and efficient functioning of the team.

Over the last three years, we have been running a Paediatric Spirometry course. The course brings

people from all over the country to Leicester to learn about performing spirometry in children. The teaching is shared out across the whole team and has received some excellent feedback over the years. We also frequently support other training courses including the Leicester Paediatric NIV course, ensuring we promote the importance of healthcare scientists as a part of the MDT.



Leicester Paediatric Spirometry course

In 2025, we were nominated for a University Hospitals of Leicester outstanding contribution award (Clinical Team) by one of the Paediatric Respiratory Medicine Consultants. The nomination mentioned "We have a fantastic team, all of whom work exceptionally hard for the children and young people we see; this nomination is a reflection of the fantastic job you all do. I couldn't ask for a better team of people to work alongside".



Team day (left to right Safiya, Charlotte, Natalie, Joe, Gemma, Prakash)

Lead Physiologist

My name is Joe Madge, I am a Clinical Scientist and Head of the Paediatric Respiratory and Sleep Physiology service. I have worked at UHL since 2014 in various roles. During my undergraduate degree in Sport and Exercise Science, I learnt about the role of a Healthcare Scientist. Upon completing my degree, I took a role as an Assistant Respiratory Physiologist at Glenfield Hospital, working with both adults and children. Glenfield supported me through my training to achieve my ARTP Practitioner qualification.

In 2019, due to expansion of the Children's services, I took a full time role at the Children's hospital and shortly after in 2022, I took on the role of Head of Service. Since joining the Children's Hospital, I successfully qualified as a Clinical Scientist by completing the STP equivalence.

Over the last four years, as a service we have been involved in the development and improvement of many children and young people (CYP) pathways. For example: Paediatric Sleep pathway, CYP asthma diagnosis pathway (including Primary care direct referral, direct and indirect bronchial challenge) and the



Joe representing ARTP workforce at NEC Respiratory Professional Care show

development of a Paediatric CPET service (here we see referrals mostly from Sports Medicine, East Midlands Congenital Heart Centre, Paediatric Respiratory and some Long COVID referrals).

I have been an ARTP member for a number of years and currently hold the position of vice-chair of the paediatrics committee and member of the workforce committee.



Higher Specialist Scientist Training Programme

In 2024, the service successfully gained a HSST training post which was awarded to Natalie. After completing STP in Leicester, Natalie joined paediatrics full time in 2021. Despite starting in a completely different kind of laboratory, studying a BSc in Cellular and Molecular Biology, she has a keen interest in paediatric respiratory and sleep and promotes paediatric training within healthcare science.

As part of the HSST, Natalie works both clinically and academically (teaching and research). Her main interest is in paediatric sleep and ventilation, acting as part of a wider MDT to support a wide range of patients with complex conditions and needs. Having successfully completed the PGDip in Leadership and Management in the Healthcare Sciences aspect of the HSST,

Natalie is now looking forward to developing her clinical competencies in both acute and long term care. She has also started her research project, focusing on paediatric sleep diagnostics, building on a range of presentations given at ERS and ARTP conferences.

Natalie is also part of the ARTP committees, acting a deputy chair of examinations and as a member of the paediatrics and sleep committees.



Natalie presenting research at ARTP conference

Future directions/developments

Having seen many service developments over the last few years, we are now focusing on optimising the newly established CYP asthma diagnostic pathway. Our objective is to improve accessibility and broaden its reach to a more diverse patient population, with a goal to improve access for communities in areas of higher deprivation across the region.

We are also developing a long-term strategy for the Consultant Clinical Scientist role, considering how this position will be integrated into the wider paediatric respiratory medicine team to support future service delivery and sustainability.

Most importantly, the team hopes to continue spreading the message that 'children are not small adults' and how enjoyable a career in paediatric physiology is!

A special thanks to Dr Caroline Beardsmore for supporting the 'History of the department' section



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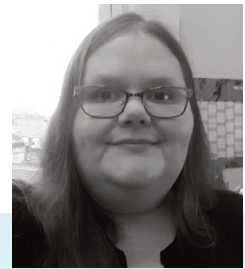
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FRESH AIR

Edited by **Dr Samantha Irvine**
ARTP Chair of Research and Innovation



Dear Reader,

Welcome back to Fresh Air. These articles are designed to communicate novel trends in research, innovation and clinical practice from both respiratory and sleep sciences. Our aim is to provoke thought and conversation within the ARTP community that we hope will benefit the future direction of physiological practice.

For this issue, we are delighted to present an article written by one of our Research and Innovation Committee members – Isobel Briggs. She recently completed the STP at Doncaster Royal Infirmary and now works at Manchester University Foundation Trust. Her article showcases her final-year STP project on the ‘Lung Health Check,’ which she undertook while working at Doncaster Royal Infirmary, prior to moving to Manchester. She highlights this screening tool as an effective, proactive measure for detecting lung cancer early, with research supporting a nationwide rollout.

A retrospective analysis of the ‘Lung Health Check’: A community-based targeted lung cancer screening pilot performed in Doncaster

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Abstract

Lung cancer is the leading cause of cancer-related deaths in the United Kingdom (UK). Once symptoms of lung cancer present, they are often non-specific and associated with advanced disease. Advanced lung cancer can preclude some treatment options, meaning patients who present with symptoms may have a reduced survival rate. There is limited evidence that a UK lung cancer screening tool will improve patient outcomes. Therefore, the aim of this project was to ascertain whether patients diagnosed with lung cancer through a screening programme, termed the ‘Lung Health Check’ (LHC), will have less progressed pulmonary disease, earlier stage of lung cancer and improved treatment options, compared to those presenting with symptoms at their GP. The LHC screens current or ex-smokers aged 55–74 years for lung cancer in Doncaster, via a Computed Tomography scan. This retrospective study compares 184 patients; 102 patients identified through the LHC and 82 patients who presented at their General Practice with symptoms of lung cancer. Pulmonary function testing was undertaken for all patients diagnosed with lung cancer to help identify planned treatments. Patients with lung cancer in the LHC group had significantly higher lung function values compared to the symptomatic patients. They also presented at an earlier stage of lung cancer which translated into a larger proportion of patients able to undergo more curative treatments including surgery. Therefore, screening patients at risk of lung cancer in the community may lead to improved outcomes.



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Introduction

Lung cancer

Lung cancer refers to malignant neoplasms present in the lung parenchyma or within the bronchi¹. It is the leading cause of cancer related deaths in the United Kingdom (UK) with 35,000 deaths in 2024². Symptoms of lung cancer typically present when the disease has progressed to a later stage³. Statistically, 71% of lung cancer is detected at stage 3 or 4, and 29% at stage 1 or 2⁴. A more advanced stage of lung cancer results in less curative treatment options and therefore, higher mortality⁴.

The asymptomatic phase of the disease encompasses a major part of its pathogenesis⁵. Numerous patients will remain symptom free regardless of radiographic or bronchoscopic evidence of a tumour⁶. Treatment options for lung cancer will differ depending on the stage of cancer and lung function testing results¹. Surgical resection is the gold standard treatment, meaning it will deliver the highest survival rate⁷. Surgery is however only offered to those with an early stage of lung cancer and preserved lung function results.

Doncaster

Doncaster exhibits a population of 310,000 citizens, and has a high smoking prevalence and lung cancer mortality rate⁸. Statistically, early stage 1 and 2 lung cancer has accounted for 22.7% of lung cancers detected in Doncaster Royal Infirmary, compared to an average of 28.7% for the whole of England. This highlights Doncaster Royal Infirmary is below the national average according to the 2019 National Lung Cancer Audit data for the 2018 cohort. This means lung cancer is diagnosed at a later stage, reducing treatment options and increasing mortality⁴.

Lung Health Check

A pilot targeted Lung Health Check (LHC) program has been implemented in deprived areas of the UK which include Doncaster, Manchester, Nottingham, Liverpool and Peterborough. Specifically, in the Doncaster area the program has been applied since March 2021, with current or ex-smokers between the ages of

55-74, registered at a Doncaster GP invited to participate. The first stage of the process involved a consultation with a lung cancer nurse and a CT scan. Patients with a positive result on the CT scan were then reviewed in an initial MDT meeting. Those patients with lung cancer then completed a full lung function test and a PET scan. After these diagnostic tests patients were then discussed in another MDT meeting so treatment options could be decided.

Aims: This project aimed to compare if patients diagnosed with lung cancer through the LHC had less advanced pulmonary disease determined by their lung function values, lower stage of lung cancer at diagnosis and improved planned treatments, compared to those diagnosed through the symptomatic pathway.

Objectives: The primary objective of this study was to determine if FEV₁ and TLco (reported as % predicted) were different in the LHC and symptomatic patients. Furthermore, the secondary objectives of this study included, identifying if the stage of lung cancer and planned treatment options differed between the LHC and the symptomatic patients, and whether a patient's lung function results could predict the stage of lung cancer.

Methods

Study design

This retrospective study involved extracting data from medical records for patients diagnosed with lung cancer based at Doncaster Royal Infirmary, dated from March 2021 to March 2023. Patients were reviewed via the use of a medical system, called 'medisec' in which all of the patient's clinic letters and diagnostic testing are stored. This allowed the lead author to review and extract all of the relevant data for this project. When extracting the data the patients were categorised into two separate groups: those identified through the LHC and those who were symptomatic and presented at their GP. Ethical approval for this study was obtained through Manchester Metropolitan University and Doncaster Royal Infirmary, through the Research and Development Department.



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Inclusion and exclusion criteria

The inclusion criteria for both groups included patients aged between 55-74 years, with no restriction on gender or existing lung conditions. Exclusion criteria included incidental findings of lung cancer.

Data collection

The following information was recorded: age, sex, smoking status (never smoker, ex-smoker, current smoker) and lung function test values, specifically FEV₁ and TLCO % predicted. The stage of lung cancer at diagnosis and planned treatment options were also documented. All of the data was recorded into an Excel spreadsheet.

Patients' lung function values

Patient's lung function measurements were obtained by following the standard operating procedures for Doncaster Royal Infirmary using the Ultima Pulmonary Function System (Medisoft, Germany). FEV₁ and TLCO measurements are presented as %predicted based on Global Lung Initiative race-specific reference equations⁹. The ARTP guidelines were followed for acceptability and reproducibility criteria¹⁰.

Statistical analysis

Statistical analyses were conducted with IBM SPSS (version 29). As the data was normally distributed an independent samples t-test was performed between the two groups for the FEV₁ and TLCO measurements. Two chi-squared tests were performed, to recognise if the stages of lung cancer and planned treatment were different between the two groups. Finally, to discover if the stage of lung cancer can be predicted from the lung function values produced, a cumulative odds ordinal logistic regression with proportional odds was performed. Statistically significant values were required at $p < 0.05$ ¹¹.

Results

Baseline characteristics

This study included 184 patients, with 102 in the LHC group and 82 in the symptomatic group. Table 1 displays the patients' baseline characteristics.

Table 1: Baseline characteristics of the two groups. Age is reported as mean $\pm$ standard deviation.

Characteristics	LHC patients (n=102)	Symptomatic patients (n=82)
Age (years)	68.2 $\pm$ 5.0	67.1 $\pm$ 5.5
Gender (M/F)	44/58	35/47
Current smoker (%)	40	51
Ex smoker (%)	60	44
Never smoked (%)	0	5

Primary outcome

The primary outcome for this study was to identify if the FEV₁ and TLCO was statistically different between the LHC and symptomatic patients. It was found that there was a statistically significant difference in the mean values of the groups, with those who were in the LHC had significantly higher FEV₁ values (87 $\pm$ 20.7%predicted) than participants in the symptomatic group (76 $\pm$ 23.6%predicted) ($t(182) = -3.4$, $p = 0.001$) with a difference of -11.1% predicted (95% CI, -17.6 to -4.7).

It was found that there was a statistically significant difference in the mean values of the groups, with those who were in the LHC had significantly higher TLCO %predicted (73.7 $\pm$ 19.5 %predicted) than participants in the symptomatic group (62.3 $\pm$ 21.2 %predicted) ($t(182) = -3.8$, $p = 0.001$) with a difference of -11.4% predicted (95% CI, -17.3 to -5.5).

Secondary outcome

A chi-square test of independence was performed to examine the association between the stages of lung cancer and the two groups (LHC and symptomatic patients). The relationship between these variables was statistically significant, $\chi^2(3) = 48.1$, $p < 0.001$. Cramer's V indicated a large strength of association between the variables, $V = 0.511$. The most frequent stage of lung cancer in the LHC was stage 1 at 71% in comparison to the symptomatic patients of stage 4 (Figure 1).

A chi-square test of independence was performed to examine the association between the planned type of cancer treatment and the two groups of patients (LHC and symptomatic patients). The relationship between these variables was statistically significant, $\chi^2(8) = 48.2$,



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$p < 0.001$. Cramer's V indicated a large strength of association between the variables, $V = 0.512$. Cross tabulation information and Figure 2 showed 71% of the LHC patients underwent surgery compared to 27% in the symptomatic group.

A cumulative odds ordinal logistic regression with proportional odds was performed to determine if the stage of cancer can be predicted from FEV₁ %predicted and TLCO %predicted. The assumption of proportional odds was met, as assessed by a full likelihood ratio test comparing the fit of the proportional odds model to a model with varying location parameters, $X^2(4) = 2.025$, $p = 0.731$. The goodness of fit for the ordinal logistic regression model was assessed using the Pearson chi-square statistic, $X^2(546) = 556.037$ with a value/df ratio = 1.018. This ratio, being close to 1, indicates that the model fits the data well. The ordinal logistic regression analysis revealed that FEV₁ %predicted is a significant predictor of cancer stage ($p = 0.007$). The odds ratio for FEV₁ %predicted was 0.977 (95% CI, 0.960 to 0.994), indicating that for each 1% increase in FEV₁ %predicted, the odds of being in a higher stage of cancer decrease by approximately 2.3%. This suggests that lower FEV₁ %predicted values are associated with more advanced stages of lung cancer. The ordinal logistic regression analysis also revealed that TLCO %predicted was not a significant predictor

$X^2(1) = 3.266$, $p = 0.071$ of lung cancer stage 0.984 (95% CI, 0.967 to 1.001).

Discussion

Few studies have directly assessed the lung function values produced in a lung cancer screening group, specifically the FEV₁ and TLCO measurements. These values are vital because they provide an insight into the effectiveness of a screening tool for respiratory clinical scientists, anaesthetists, lung cancer nurses and respiratory consultants¹². This lung function information is also used to determine a suitability for surgery¹³⁻¹⁶. The novel findings displayed in Table 1 highlight a significant difference between the FEV₁ and the TLCO measurements between the two groups. Specifically, the FEV₁ and TLCO measurements were significantly higher by 11.1% and 11.4% in the LHC group respectively. This increase in measurement meant more patients were above an FEV₁ and TLCO >60% predicted, meaning they were eligible to have surgery as a planned treatment^{14,15,17}. Recent findings by Li *et al*¹⁸ display a far greater five-year survival rate at 80.3% in patients who underwent surgery as opposed to chemotherapy and radiotherapy, which showed only a survival rate of 16-32%¹⁹.

The stage of lung cancer has been used to assess the success of a lung cancer screening tool whereby Gartman *et al*²⁰ screened 3,386

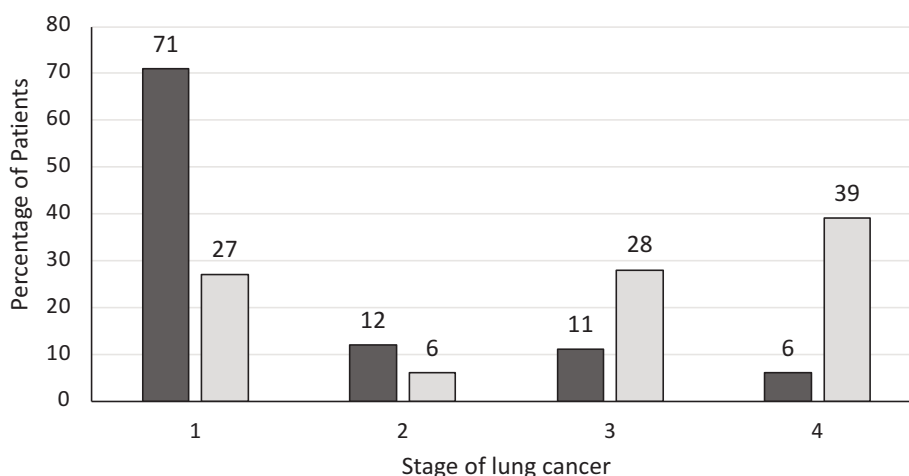


Figure 1. Displays the percentage of patients diagnosed with each stage of lung cancer. LHC patients n=102 (dark grey box) symptomatic patients n=82 (light grey box).



FRESH AIR

veterans, showing 98 patients (2.9%) were diagnosed with lung cancer. Of those who were diagnosed with lung cancer, 48% were in stage 1 with 34.7% in stage 3 or 4. In our study, 71% of the LHC patients were in stage 1 and 17% in stage 3 or 4, as can be seen in Figure 1. The difference between the percentages for the current study and Gartman *et al*²⁰ may be because Gartman focused on veterans, who could have been exposed to additional harsh chemicals, leading to more advanced lung cancer compared to ex/current smokers²¹. Two other screening studies by Gohagan *et al*²² and Abraham *et al*²³ discovered 48% and 63% of patients screened had stage 1 lung cancer respectively. The difference in percentage between these two studies and the current findings could be due to advancements in CT scans. Interestingly, Tárnoki *et al*²⁴ identified advancements in high-resolution CT scans that have resulted in clearer and more detailed images of the lungs. Moreover, the emergence of artificial intelligence and machine learning algorithms have revolutionised CT scans, allowing accurate diagnosis and staging of lung cancer²⁴.

There is a statistically significant difference in the planned treatment for the LHC and the symptomatic population. Specifically, 71% and 27% of the patients had surgery as a planned treatment in the LHC and the symptomatic population respectively, as can be seen in

Figure 2. This shows the LHC population had a far greater likelihood of surgery, which is the best curative treatment and likely to decrease mortality^{25,26}. When no cure is achievable patients are offered specialist palliative care; in total 5% and 17% of the LHC and symptomatic group respectively underwent this treatment²⁷.

An interesting finding in this study indicated that for each 1% increase in FEV₁ %predicted, the odds of being in a higher stage of lung cancer decreased by approximately 2.3%. This discovery is similar to a study conducted by Purdue *et al*²⁸ where there was an increased rate of lung cancer in patients which showed a mild, moderate or severe reduction in the FEV₁.

Conclusion

Overall, the results of this study demonstrated that the LHC initiative is associated with diagnosis of lung cancer at an earlier stage with more preserved pulmonary function, and hence greater use of curative treatments, specifically surgery. This adds to the current literature, identifying lung cancer screening tools are an effective proactive measure of catching lung cancer early, leading to better patient outcomes. These findings strongly support the continued use of the Lung Health Check in the Doncaster area and implementation of a nationwide roll out.

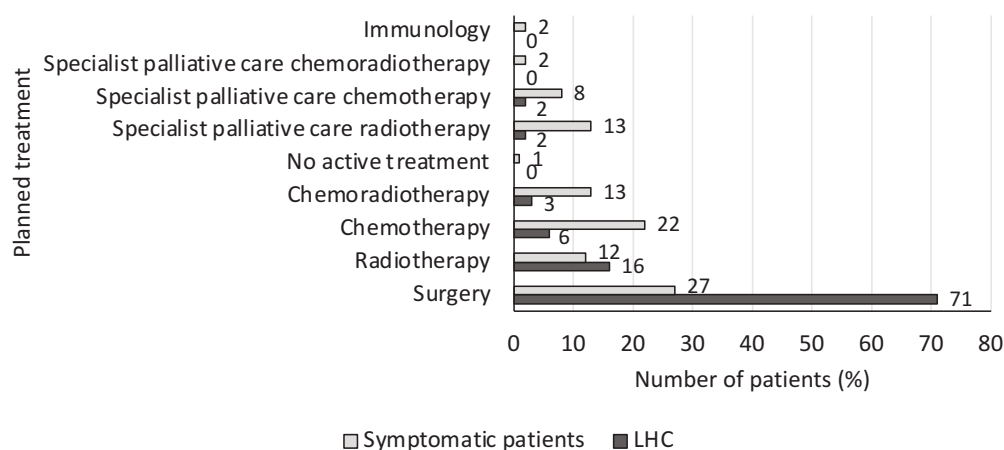


Figure 2. Displays the percentage of patients with their planned treatment. LHC patients n=102 (light grey box) symptomatic patients n=82 (dark grey box).



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Due to this programme in the UK being in its infancy, future research should be directed into investigating the long-term effects of this programme on patient mortality at five to ten years.

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Desaturation Thresholds

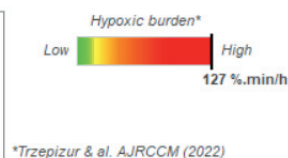
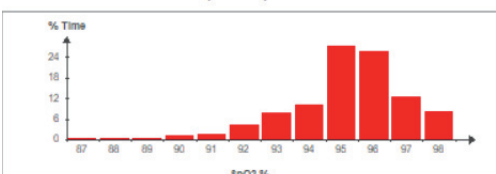
AHI counts the number of breathing events per hour of sleep but not how severe they are. People can have the same AHI yet very different levels of desaturations, cardiovascular strain, and sleep disruption.

AHI doesn't capture the depth or duration of desaturations, therefore may miss the real physiological impact of sleep apnoea.

Why should clinicians pay attention?

Hypoxic Burden (HB) predicts outcomes better than AHI because it reflects the true "dose" of overnight desaturation. It highlights physiological stress that AHI can miss—crucial in patients with comorbidities or ongoing symptoms.

SpO2 Saturation	
ODI (3%)	18.9 evts/h
Longest desat.	112 s
Min.	87 %
Max.	99 %
Aver.	95 %
% time ≥ 90%	98.9 % (498.3 min)
% time < 90%	1.1 % (5.8 min)
% time < 85%	0.0 % (0.0 min)
% time < 80%	0.0 % (0.0 min)



How Sefam Analyse Helps Manage This Problem

Sefam Analyse works with Sefam CPAP devices and Bluetooth oximetry to give a clearer view of therapy.

It combines:

- visual CPAP therapy analysis
- integrated SpO₂ and pulse-rate data
- event scoring and PolyLink polygraphy
- automatic and manual review tools

This delivers a more complete picture of therapy effectiveness than AHI or compliance alone.



How Sefam Analyse Addresses Hypoxic Burden

SASHB: Calculates hypoxic burden using only desaturations linked to scored respiratory events.

HB(oxi): Calculates hypoxic burden using all ≥2% desaturations, even those not tied to scored events.

What HB Measurement Allows You to Do

Optimise therapy: Detect residual desaturation and adjust treatment.

Refine risk: Use HB's stronger outcome link to improve risk assessment.

Track progress: Monitor real physiological change beyond AHI.

Reveal hidden hypoxia: Identify non-apnoea-related desaturation.

How PolyLink Enhances This Further

- Adds on-therapy 10 channel polygraphy with HD respiratory effort and position signals.
- Provides PLK scoring with auto/manual review and waveform editing.
- Improves troubleshooting, event differentiation, desaturation validation, and phenotype insight.



ON THE BLOWER

Paul Burns
ARTP INSPIRE Editor

The Manufacturer Liaison Committee would like to hear from current users of Koko lung function equipment. We are interested in understanding your most recent experience of the kit and service provided. To get in contact please email MLCenquiries@artp.org.uk.

ARTP National Strategy day December 2025

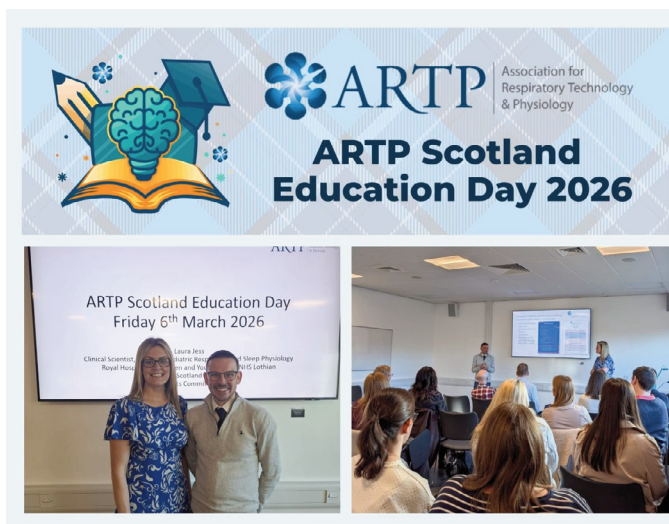
The National Strategy Day took place at the BCEC in Birmingham on the 12th of December, with excellent attendance from heads and deputy heads of service. As always, the event was strongly supported by our industry partners. The programme featured committee updates followed by sessions on data modelling, workplace efficiency, and achieving STP equivalence.

Isobel Briggs delivered a particularly engaging and interactive session on neurodiversity in the workplace, offering valuable insights and plenty of food for thought.

The final session of the day covered a diverse range of topics including home spirometry, breathlessness pathways, healthcare scientist led sleep pathways, and the use of databases to drive innovation. Delegates left with a wealth of ideas to consider and potential initiatives to take back to their own services.



ARTP Scotland Rejuvenation – Education day



ARTP Scotland has recently revitalised its regional committee, now led by Chair Laura Jess, Vice Chair Sara McArthur, Secretary Scott Tart, Education Lead Paul Burns, and Vice Education Lead Vicky Zgardzinski. To mark this fresh start, the team delivered a free Education Day for ARTP members on Friday 6th March – complete with a special guest appearance from our very own Matt Rutter.

Held in the Teaching and Learning Centre at the Queen Elizabeth University Hospital, Glasgow, the event welcomed 35 delegates and received strong support from five industry



partners. The programme featured a series of insightful talks from physiologists and consultants across Scotland, showcasing current practice, service development, and shared learning.

The final session highlighted the growing role of physiologist led ILD and sleep clinics, offering an inspiring look at the advanced practice being undertaken across Scottish services to streamline patient pathways and improve care.

The Barbara Oatway Award was also re introduced, with five physiologists delivering oral abstract presentations in memory of Barbara, who served as Lead Respiratory Physiologist at Forth Valley Royal Hospital for over 20 years, as well as a national assessor and former ARTP Scotland Secretary. She sadly passed away at the age of 53, and it is fitting that her legacy continues through this award.

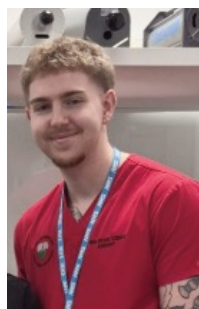
The deserving joint winners were Emma Giffen, Highly Specialised Respiratory Physiologist at NHS Greater Glasgow and Clyde, and Beth McCartney, first year STP trainee at the Royal Hospital for Children, Glasgow.



L-R Vicky, Beth, Emma and Paul

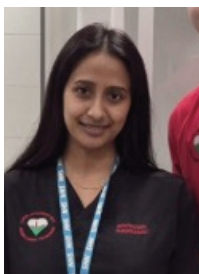
Healthcare Science Week: A Window into the Cardiopulmonary Scientists at Prince Charles Hospital

Cwm Taf Morgannwg University Health Board, Merthyr Tydfil



Elis, Senior Healthcare Scientist Assistant

I decided to join the Healthcare Science team in Sleep and Respiratory because, during my Exercise Science degree, I developed a strong interest in respiratory physiology—particularly through studying CPET and the impact of respiratory health on performance and overall well-being. I wanted to deepen my knowledge and gain hands-on clinical experience in this field. The team has been incredibly welcoming, supportive, and inspiring, which has made the transition even more rewarding. I'm really excited to continue learning and working towards becoming a fully qualified Sleep & Respiratory Physiologist.



Fatema, Respiratory Physiologist

I became a Respiratory and Sleep Physiologist after discovering my passion for the specialty during a respiratory placement as a nursing student. It was there that I was first exposed to the diagnostic side of sleep medicine, and I quickly realised how much I enjoyed the investigative, problem-solving aspect of identifying and managing sleep-disordered breathing. I was particularly drawn to the way diagnostics and therapy work hand in hand to make a real difference to patients' quality of life.

My interest deepened further when I completed my dissertation on "*The Impact of Sleep Disordered Breathing on Maternal Health in the Third Trimester of Pregnancy*." Researching this topic reinforced how significant sleep health is, not only for day-to-day well-being but also for wider maternal and fetal outcomes. That experience solidified my decision to pursue a career in respiratory and sleep physiology, where I could combine clinical diagnostics, evidence-based practice, and long-term patient care. For Healthcare Science Week, I will be at Techniquet Science Museum, Cardiff Bay, to encourage children to have an interest in lungs and science.



Sandra, HCPC Clinical Scientist (Respiratory & Sleep)

I accidentally fell into the Respiratory Physiology world having not achieved the A-level grades for Radiotherapy training and I haven't looked back since.

I started my training thirty-nine years ago in the Lung function department at Llandough Hospital, Cardiff, as a Student Physiological Measurement Technician, yes PMT for short and was constantly ribbed by the fabulous group of colleagues I worked alongside.

Back in the day, the training involved in-service manual competencies and one day release to Technical College to study first O-Tec, and then HNC in Medical Physics and Physiological Measurements, alongside sitting the national professional qualifications with ARTP / BTS.

I passed the Master's module in *Clinical assessment and history taking* at Swansea University in 2014, which sparked my interest in sleep medicine – a service I now lead for two district general hospitals within Cwm Taf Morgannwg University Health Board (CTMUHB).

Over the years, I have had the privilege to represent Welsh Respiratory and Sleep Physiologists at WASC, RIG and Welsh Government level. I have served on the ARTP Education committee, including roles as the Examination standards Chair and CPD officer, and I am currently the Honorary Vice Chair of the ARTP Board and Council.

In 2021, I was honoured to receive the ARTP Scientist of the Year Award. In 2018, I achieved equivalence through the AHCS, becoming an HCPC registered Clinical Scientist in Respiratory and Sleep. I now work autonomously to deliver specialist care and therapy in sleep-disordered breathing, run specialist asthma diagnostic pathways and lead a CPET service.

Manufacturer news



In December NuvoAir UK announced it would be closing UK operations. They provided remote monitoring solutions focussing on spirometry and remote diagnostic pathways with results overseen by physiologists. The company cited several contributing factors to its closure in the UK including: Limited and inconsistent NHS funding for innovation, global economic pressures on small digital health companies and difficulty in sustaining a UK-specific commercial model.



In February 2026, Radiometer, which is owned by Danaher Corporation announced it would acquire Masimo in a ~ \$9.9 billion all cash deal which is expected to close in the second half of 2026 subject to regulatory approval. They will run as sister companies with radiometer continuing to specialise the blood gas and transcutaneous monitoring area whilst Masimo will continue with its specialist pulse oximetry and advanced haemoglobin and oxygenation metrics.



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