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LUNG FUNCTION

Determinants and Follow-up of Lung Function Data from a Predominantly First Nations Cohort of Adults Referred to Specialist Respiratory Outreach Clinics in Regional and Remote Queensland

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Abstract

Purpose Northern Territory (NT)-based clinical service data suggest substantial lung function impairment amongst First Nations adults as young as 18–40 years. Our objectives were to describe the burden of disease and lung function of adults living in regional-remote Queensland, identify determinants of lung function, and evaluate the impact of a specialist respiratory outreach service on lung function.

Methods Retrospective 8-year cohort study (February 2012–March 2020) of 1113 First Nations Australian adults (and 648 non-First Nations adults) referred to respiratory outreach clinics in regional-remote Queensland.

Results In the combined cohort, the forced expiratory volume in 1 s (FEV_1) was clinically abnormal for 54% of First Nations patients (51% of non-First Nations patients), forced vital capacity (FVC) for 46% (36%), FEV_1/FVC% for 30% (36%), and gas diffusing capacity (D_{LCO}) for 44% (37%). A respiratory diagnosis was assigned by a respiratory physician in 78% of First Nations (76% non-First Nations) patients. Smoking, household smoke exposure, underweight BMI, and respiratory disease were associated with reduced lung function. In the 40% of patients (709/1765) followed up, FEV_1 and FVC significantly improved (mean change: $zFEV_1 = 0.15$ [95% CI 0.10–0.20]; $zFVC = 0.25$ [0.20, 0.31]), and FEV_1/FVC% significantly reduced (mean $= -0.10$ [95%CI -0.07 to -0.03]), with no significant change in D_{LCO}. Patients with COPD had lower FEV_1 improvement, whilst underweight and obese patients had lower FVC improvement.

Conclusion Regional-remote First Nations adult Queenslanders have higher lung function than previously reported, with no lung function decline observed at follow-up visit, including for those with respiratory disease.

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Introduction

Australians are amongst the healthiest people in the world, comparing favourably to other countries in all areas except for alcohol consumption and rate of obesity [1]. Continued improvements to life expectancy have been coupled with reduced years of ill health, but these improvements are not ubiquitous. For the 29% of Australians living in rural and remote areas [1], there is significantly increased risk of disease-associated morbidity and mortality (up to 1.7 times in outer regional and remote areas) relative to Australians living in urban areas [2]. Reasons for this health inequality are complex; contributing factors include financial and logistical barriers to accessing healthcare and social determinants of health [2].

Health gaps are further heightened amongst Aboriginal and/or Torres Strait Islander Australians (henceforth respectfully referred to as First Nations), who are disproportionately affected by a range of chronic diseases that account for 77% of the mortality gap between First Nations and non-First Nations peoples [3]. There are many reasons for this gap but the lack of culturally appropriate services is one factor that likely contributes to inadequate healthcare access [4]. Within the literature, culturally appropriate outreach services have been shown to improve outcomes [4, 5]. Indigenous Respiratory Outreach Care (IROC), a culturally appropriate specialist respiratory service that delivers care to regional and remote Queensland communities with high proportions of First Nations Australians, was established in 2011 [6]. IROC, staffed by First Nations project officers and respiratory physicians, nurses, physiotherapists, and respiratory scientists, engages with community Elders groups and works closely with local primary care teams (community doctor, nurse, and First Nations health workers). These local teams refer patients to the IROC service and implement the delivery of the suggested clinical management. The value of IROC has been objectively demonstrated for children where it was found that the spirometric lung function of First Nations children with asthma and bronchiectasis significantly improved following at least 12 months of IROC specialist care service [7]. We further showed that these improvements were comparable to those of children seen at tertiary paediatric facilities in Brisbane [8]. To date, there has been no published objective evaluation of any culturally appropriate respiratory service for First Nations adults.

The two largest reported contributors to lung disease in First Nations adults are chronic obstructive pulmonary disease (COPD) [1] and asthma (3.0 and 1.9 times more common in First Nations compared with non-First Nations Australians [3], respectively) [9]. These data were obtained from epidemiological studies which may be inaccurate as both conditions have high disease misclassification (as high as 31% for COPD) [10]. Accurate diagnostic data from a large cohort of adults would contribute to the current sparsity of First Nations specific data.

Lung function tests are important for diagnosing and monitoring lung disease [11, 12]. Further, spirometry values (particularly forced expiratory volume in 1 s, FEV_1) independently predict future respiratory and cardiovascular morbidity and all-cause mortality, with an effect size greater than traditional risk factors such as smoking and hypertension [13]. These relationships are particularly important to First Nations Australians, who have a high respiratory and cardiovascular disease morbidity and mortality burden [3]. Despite its importance, published lung function data for First Nations adults are sparse. Existing data suggest that significant lung function derangement is common amongst First Nations adults as young as 18–40 years [14], particularly in the presence of bronchiectasis and COPD where severe airflow limitation is present in the majority of patients seen at respiratory clinics [15, 16].

To address these important knowledge gaps, we evaluated the lung function data of 1765 adults (1113 First Nations Australians) who received specialist clinical care through IROC clinics. Our study's objectives were to (i) describe the lung function and burden of respiratory disease within these populations, (ii) determine factors that impact on lung function, given its importance to overall health and utility as a predictor of future outcomes [10], and (iii) determine whether the IROC service has any impact on the lung function of adults treated by analysing follow-up spirometry.

Methods

Study Design, Setting, and Participants

This was an 8-year cohort study (February 2012–March 2020) of adults referred to the IROC service through their primary care physicians, First Nations health workers, or self-referral. Data were prospectively collected as part of the service.

Clinics were held in regional and remote Queensland communities. Inclusion criteria were adults aged > 18 years at first IROC clinic visit, who were medically reviewed and had spirometry and/or gas diffusion tests performed by a respiratory scientist. Although IROC focuses on First Nations Australians, non-First Nations adults within these communities were also referred to the service. Ethical approval was granted by The Prince Charles Hospital Human Research Ethics Committee (HREC/2019/QPCH/58452).

Lung Function Testing

Spirometry and gas diffusion testing were performed according to American Thoracic Society (ATS) and European Respiratory Society (ERS) criteria [11, 12] on either EasyOne Lab or EasyOne Pro Lab (ndd Medizintechnik) portable machines. Global Lung Function Initiative (GLI) 2012 reference values [17] were applied to spirometry tests, and GLI 2017 reference values [18] were applied to gas diffusion tests, to derive Z-scores for each patient (see the supplement for more information on Z-score usage in lung function testing). This study uses re-calculated gas diffusion reference values issued in a correction by the GLI in October 2020 [19]. For patients > 85 years, the Miller 1983 reference equations were used for gas diffusion tests [20]. The GLI 2012 "Other/mixed" classification was used for spirometry for patients who self-identified as First Nations [21]. For

all other patients, the "Caucasian" classification was used. Pre-bronchodilator spirometry was used for all lung function analysis except for Global Initiative for Chronic Obstructive Lung Disease (GOLD) [22] staging, where post-bronchodilator spirometry was used.

Data Verification

Patient demographics, lung function data, respiratory diagnosis as confirmed by a respiratory physician, comorbidities, smoking behaviours, and secondary smoke exposure were collected at each clinic visit and stored electronically. Missing information was filled where possible using electronic and paper chart medical records. Patients were excluded from the study if there were gaps in data.

Statistical Analysis and Definitions

Data distributions were examined visually and numerically. Non-parametric tests were used for non-normally distributed data whilst parametric tests were used for normally distributed data. Pre-bronchodilator spirometry and gas diffusion measurements at baseline and follow-up were normally distributed. Pre-bronchodilator spirometry data was used for both baseline and follow-up visits. Follow-up spirometry and gas diffusion tests were selected using the highest FEV_1 and D_{LCO} Z-scores occurring within the last 12 months of care, and at least 3 months after baseline testing. GLI 2012-derived Z-scores were used for statistical analysis; however, we also present baseline lung function as percentages of predicted (% predicted) values for various diagnoses to enable comparison with other cohort studies using % predicted values (see the supplement for more information).

Baseline spirometry and gas diffusion data were examined using multivariable regression modelling of baseline FEV_1, FVC, FEV_1/FVC%, and D_{LCO} Z-scores. Main effects were fit for age, BMI, sex, First Nations status, smoking, household smoking, and respiratory disease. Regression coefficients and their associated 95% confidence intervals (95%CI) and p-values were reported. Changes (Δ) in FEV_1, FVC, FEV_1/FVC%, and D_{LCO} Z-scores (difference between baseline and follow-up) were modelled similarly, with duration of care as an added covariate. Stata 16.1 (StataCorp LLC) was used for statistical analyses; 2-tailed p-values < 0.05 were considered significant.

Results

Cohort Summary

Of the 1853 patients with lung function data, our final cohort consisted of 1765 adults (Fig. 1). Demographic and respiratory diagnosis data for the cohort ($n = 1765$) are summarised in Table 1, with baseline lung function including GOLD [22] staging for COPD summarised in Table 2. First Nations adults were younger, more likely female, and more likely to smoke and be exposed to second-hand household smoke when compared to non-First Nations adults.

Spirometry and Gas Diffusing Capacity

Multivariable regression showed that BMI, First Nations status, smoking (including second-hand household exposure), and respiratory diagnosis significantly influenced lung function (Table 3). Those with COPD (mean $FEV_1 = 58\%$ predicted, SD = 21; FVC = 74% predicted, SD = 19; FEV_1/FVC = 62%, SD = 16; $D_{LCO} = 64\%$ predicted, SD = 22), bronchiectasis (mean $FEV_1 = 63\%$ predicted, SD = 25; FVC = 73% predicted, SD = 23; FEV_1/FVC = 67%, SD = 13; $D_{LCO} = 77\%$ predicted, SD = 26), and pulmonary hypertension (mean $FEV_1 = 55\%$ predicted, SD = 21; FVC = 65% predicted, SD = 19; FEV_1/FVC = 66%, SD = 13; $D_{LCO} = 63\%$ predicted, SD = 24) had significantly poorer lung function compared with those without these diseases.

Follow-Up

Of the 1765 patients in the cohort, 709 (40%) attended clinically for follow-up review visits. The median duration of care (from baseline to last visit to IROC) was 17 months (IQR 6, 36). Of the 709 patients who were followed up, 698 had spirometry performed. Supplement Table S1 compares the demographics and lung function data of those patients who were followed up to those who were not. Patients who followed up clinically were more likely to have respiratory disease and associated poorer lung function.

We found significant increases in mean $zFEV_1$ and zFVC with a significant decrease in $zFEV_1$/FVC (Table 4). Regression analyses found improvements to FEV_1 and FVC at follow-up to be similar for most demographic factors and respiratory diagnosis. However, we found weak evidence that for the overweight and obese groups, increases in FVC were significantly lower ($\beta = -0.38$, $p < 0.01$; $\beta = -0.21$, $p = 0.02$) than the normal group (full regression presented in Table 4), and decreases in FEV_1/FVC were greater for First Nations patients ($\beta = -0.17$, $p = 0.03$).

Follow-up gas diffusion testing of 253 of 709 patients showed no significant changes in zD_{LCO} (Table 4). This result was similar across demographic and respiratory diagnosis categories except for former smokers (vs. never smokers) ($\beta = -0.46$, $p = 0.02$).

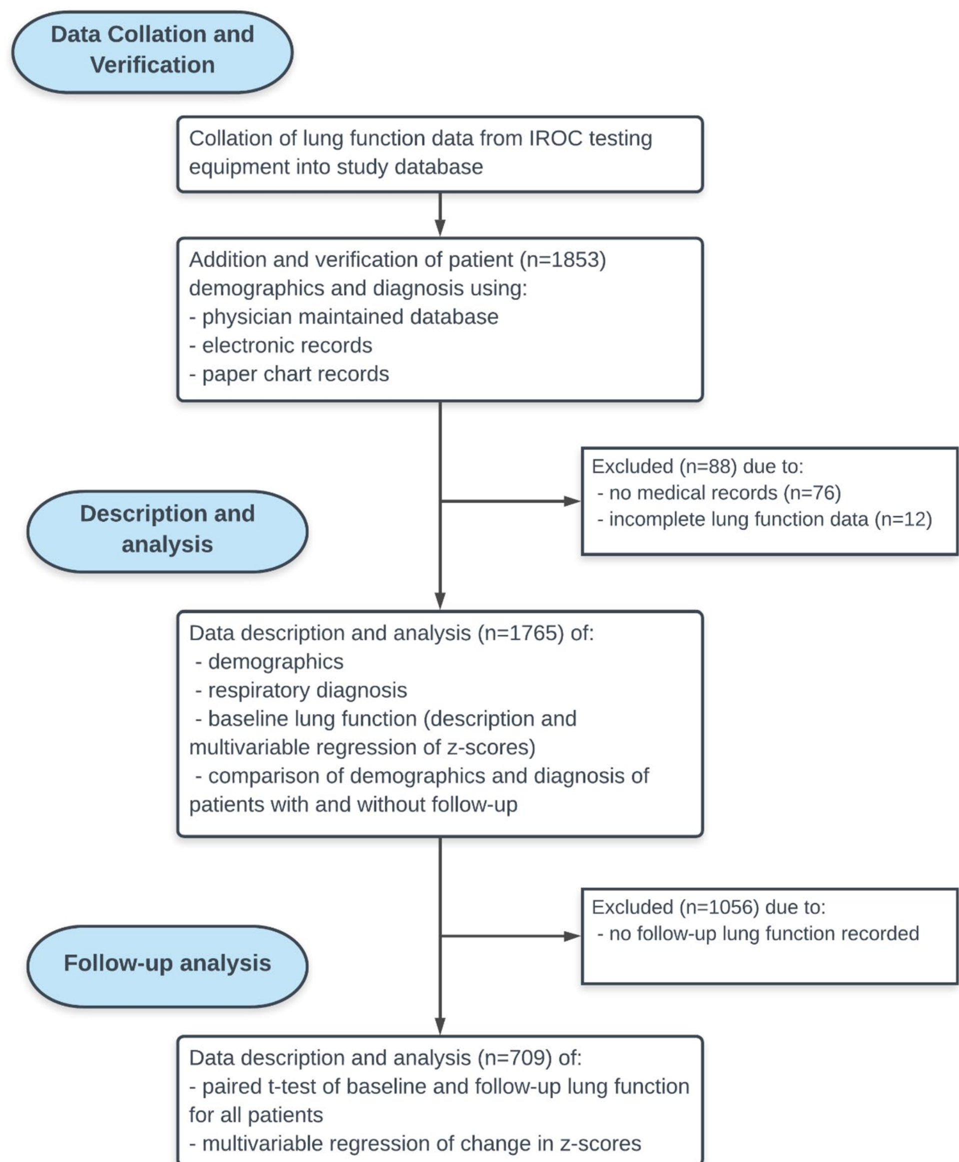

Fig. 1 Flow diagram of study data collection, verification, and analysis

Discussion

In our study involving spirometry and gas diffusing capacity of 1765 adults (approximately two-thirds First Nations) managed by specialist respiratory outreach teams in Queensland, we found baseline FEV_1 *Z*-scores were below the clinical normal range (defined as -1.64 and above) for the 52% of the whole cohort, and for 54% of the First Nations group (Table 2). Baseline FVC Z-scores were clinically abnormal for 42% of patients (46% First Nations), baseline FEV_1/FVC% for 32% (30% First Nations), and gas diffusing capacity (D_{LCO}) for 42% (44% First Nations). Baseline mean FVC, FEV_1/FVC, and D_{LCO} Z-scores were within the clinically normal range. The majority (77%) of patients were assigned a respiratory diagnosis, with COPD, asthma, and OSA the most common diagnoses seen and treated. Diagnosed respiratory disease, smoking, second-hand household smoke exposure, and below normal BMI were associated with reduced lung function. At follow-up, there were statistically significant improvements in lung function, with increased mean FEV_1 and FVC and significant decline in FEV_1/FVC%, whilst D_{LCO} was unchanged ($p > 0.05$).

Our study of adults managed at a specialist respiratory outreach service within an IROC model is the first such report in Australia. To our knowledge, only two similar Australian studies exist [14, 16], but neither examined follow-up data nor factors that influenced lung function data. Both previous studies were retrospective and reported on First Nations patients seen at respiratory outreach services within the Northern Territory (NT) [14, 16]. The NT-based study's findings were different to ours in the following ways: (i) the mean FEV_1 values reported (55% [14] and 42% [16]

Table 1 Summary of patient demographics and lung function at first presentation to IROC clinics

		Whole group $n = 1765$	First nations $n = 1117$	Non-first nations $n = 648$
		Median (IQR) or n (%)		
Age (years)		57 (48–67)	55 (45–64)	63 (53–72)
BMI (kg/m^2)	Underweight (< 18.5)	83 (5%)	55 (5%)	28 (4%)
	Normal (18.5–24.9)	340 (19%)	198 (18%)	142 (22%)
	Overweight (25–29.9)	428 (24%)	247 (22%)	181 (28%)
	Obese (≥ 30)	914 (52%)	617 (55%)	297 (46%)
Female		1027 (58%)	689 (62%)	338 (52%)
Smoking	Current	606/1585 (38%)	477/1044 (46%)	129/541 (24%)
	Former	565/1585 (36%)	327/1044 (31%)	238/541 (44%)
	Never	414/1585 (26%)	240/1044 (23%)	174/541 (32%)
Household smoke		570/1396 (41%)	447/945 (47%)	123/451 (27%)
Respiratory disease burden	No diagnosis	399 (23%)	246 (22%)	153 (24%)
	1 diagnosis	851 (48%)	561 (50%)	290 (45%)
	2 diagnosis	409 (23%)	262 (25%)	147 (23%)
	3 + diagnosis	106 (6%)	48 (4%)	58 (9%)
Common respiratory diagnoses[a]	COPD	623 (35%)	394 (35%)	229 (35%)
	Asthma	574 (33%)	379 (34%)	195 (30%)
	OSA	352 (20%)	242 (22%)	110 (17%)
	Bronchiectasis	70 (4%)	39 (4%)	31 (5%)
	Pulm hypertension	39 (2%)	20 (2%)	19 (3%)

COPD chronic obstructive pulmonary disease, *OSA* obstructive sleep apnoea

[a]Patients may have concurrent respiratory diagnoses

Table 2 Summary of lung function at first presentation to IROC clinics, including GOLD staging of patients with COPD

		Whole Group $n = 1765$	First Nations $n = 1117$	Non-First Nations $n = 648$
		Mean (SD)		
Spirometry ($n = 1734$)	FEV_1 (% pred)	72 (23)	72 (22)	72 (25)
	FEV_1 (Z-score)	− 1.81 (1.43)	− 1.84 (1.41)	− 1.76 (1.49)
	FVC (% pred)	80 (19)	80 (19)	81 (19)
	FVC (Z-score)	− 1.44 (1.38)	− 1.53 (1.44)	− 1.27 (1.27)
	FEV_1/FVC (%)	71 (14)	73 (13)	69 (15)
	FEV_1/FVC (Z-score)	− 1.06 (1.64)	− 1.01 (1.64)	− 1.56 (1.64)
Gas diffusing capacity ($n = 1297$)	D_{LCO} (% pred)	81 (25)	81 (24)	82 (26)
	D_{LCO} (Z-score)	− 1.45 (1.92)	− 1.51 (1.87)	− 1.34 (1.99)
GOLD (post-bronchodilator)		*n* (%)		
COPD & FEV_1/FVC < 0.70				
GOLD 1 (mild)	FEV_1 ≥ 80% pred	64/375 (17%)	48/248 (19%)	16/127 (13%)
GOLD 2 (moderate)	FEV_1 50–79% pred	203/375 (54%)	137/248 (55%)	66/127 (52%)
GOLD 3 (severe)	FEV_1 30–49% pred	84/375 (22%)	51/248 (21%)	33/127 (26%)
GOLD 4 (very severe)	FEV_1 < 30% pred	24/375 (6%)	12/248 (5%)	12/127 (9%)

GOLD global initiative for chronic obstructive lung disease. *COPD* chronic obstructive pulmonary disease. *Pred* predicted

predicted) were well below that of the First Nations adults at IROC clinics (72% predicted) despite similar age distributions, and (ii) marked differences in bronchiectasis incidence between our First Nations cohort (4%) compared to the NT studies that reported 19% [14] and 50% [16] incidence rates, respectively. In one instance, the reference values used were not disclosed by the authors [16], whilst the National Health and Nutrition Examination Survey III (NHANES III) [23]

Table 3 Regression testing the effects of demographics and respiratory diagnoses on baseline lung function Z-scores

		$zFEV_1$ ($n = 1734$)		zFVC ($n=1734$)		$zFEV_1$/FVC% ($n=1734$)		zD_{LCO} ($n=1297$)	
		β (95%CI)	p	β (95%CI)	p	β (95%CI)	p	β (95%CI)	p
Age (10 years)		− 0.04 (− 0.08, 0.01)	0.13	− 0.05 (− 0.09, 0.00)	0.07	− 0.02 (− 0.07, 0.00)	0.43	− 0.23 (− 0.30, − 0.17)	< 0.01
BMI[a]	Underweight	− 0.47 (− 0.78, − 0.15)	< 0.01	− 0.40 (− 0.72, − 0.08)	0.02	− 0.24 (− 0.59, 0.11)	0.18	− 1.17 (− 1.60, − 0.73)	< 0.01
	Normal	Reference	–	Reference	–	Reference	–	Reference	–
	Overweight	0.20 (0.01, 0.38)	0.08	0.11 (− 0.09, 0.30)	0.28	0.30 (0.09, 0.51)	< 0.01	0.31 (0.04, 0.57)	0.02
	Obese	0.08 (− 0.09, 0.25)	0.60	− 0.13 (− 0.31, 0.05)	0.15	0.46 (0.26, 0.65)	< 0.01	0.83 (0.58, 1.08)	< 0.01
Sex	Female	0.06 (− 0.07, 0.19)	0.36	− 0.02 (− 0.15, 0.12)	0.80	0.21 (0.07, 0.35)	< 0.01	− 0.05 (− 0.22, 0.13)	0.60
First Nations		− 0.08 (− 0.21, 0.06)	0.27	− 0.26 (− 0.40, − 0.12)	< 0.01	0.11 (− 0.05, 0.26)	0.17	− 0.44 (− 0.62, − 0.25)	< 0.01
Smoking	Current	− 0.30 (− 0.48, − 0.12)	< 0.01	− 0.15 (− 0.33, 0.04)	0.13	− 0.31 (− 0.52, − 0.11)	< 0.01	− 0.12 (− 0.37, 0.13)	0.33
	Former	− 0.30 (− 0.48, − 0.13)	< 0.01	− 0.15 (− 0.33, 0.03)	0.09	− 0.40 (− 0.59, − 0.20)	< 0.01	− 0.22 (− 0.46, 0.02)	0.07
	Never	Reference	–	Reference	–	Reference	–	Reference	–
Household smoke		− 0.20 (− 0.35, − 0.06)	< 0.01	− 0.23 (− 0.38, − 0.08)	< 0.01	− 0.02 (− 0.18, 0.14)	0.80	− 0.16 (− 0.35, 0.04)	0.11
Asthma ($n=574$)		− 0.29 (− 0.43, − 0.15)	< 0.01	− 0.06 (− 0.20, 0.08)	0.40	− 0.55 (− 0.71, − 0.40)	< 0.01	0.58 (0.39, 0.77)	< 0.01
COPD ($n=623$)		− 1.07 (− 1.22, − 0.92)	< 0.01	− 0.58 (− 0.73, − 0.43)	< 0.01	− 1.27 (− 1.44, − 1.11)	< 0.01	− 1.40 (− 1.60, − 1.20)	< 0.01
OSA ($n=352$)		0.10 (− 0.07, 0.26)	0.24	− 0.07 (− 0.24, 0.10)	0.42	0.29 (0.11, 0.48)	< 0.01	0.29 (0.07, 0.51)	0.01
Bronchiectasis ($n=70$)		− 0.44 (− 0.76, − 0.12)	< 0.01	− 0.44 (− 0.77, − 0.12)	< 0.01	− 0.32 (− 0.68, 0.03)	0.07	− 0.10 (− 0.53, 0.33)	0.65
Pulm htn ($n=39$)		− 0.84 (− 1.21, − 0.48)	< 0.01	− 0.82 (− 1.26, − 0.37)	< 0.01	− 0.36 (− 0.84, 0.12)	0.14	− 1.10 (− 1.69, − 0.52)	< 0.01

Regression model adjusted for patient age

[a]BMI categories: Underweight (< 18.5 kg/m^2), Normal (18.5–24.9 kg/m^2), Overweight (25–29.9 kg/m^2), Obese (≥ 30 kg/m^2). Abbreviations: COPD, chronic obstructive pulmonary disease. OSA, obstructive sleep apnoea. Pulm htn, pulmonary hypertension

values, without ethnic correction, were used in another [14]. NHANES III reference values give higher predicted values and therefore lower Z-scores than the GLI 2012 "Other/mixed" for any given raw value, and so these differences in reported lung function between our study and previous NT studies are likely overestimated. These differences therefore detract from the comparability of absolute values *Z*-scores and % predicted values reported. Possible reasons for actual disparity in lung function may include timelier referral by primary care physicians and IHWs in the Queensland model, and differences in patient sampling (a proportion of patients are referred for respiratory health checks).

Our clinical review follow-up cohort was small (only 40% of IROC patients had follow-up lung function) and had poorer lung function than those not followed up. Reasons for the relatively small group include: (i) patients ($n=253$) not assigned a respiratory diagnosis (many of whom were respiratory health check referrals), were more likely to be discharged back to their primary care team and not seen for follow-up, (ii) 11% ($n=201$) of patients included at baseline are known to have died at the time of writing, and (iii) some had moved away from IROC clinic sites.

Changes in follow-up spirometry (improvements in $zFEV_1$ and zFVC, reduction in $zFEV_1$/FVC%) were similar across most demographic factors and respiratory diagnosis, except for COPD and underweight patients where changes in $zFEV_1$ and zFVC were smaller, respectively, and First Nations patients who had a larger reduction in $zFEV_1$/FVC%. The prognostic value of lung function, particularly FEV_1 as a prognostic marker of mortality, has been well established within the literature [24], and was demonstrated clearly in the PURE [13] study. Given the importance of lung function, particularly within at-risk populations such as those in regional and remote areas [2] and First Nations

Table 4 Mean changes in lung function Z-scores from baseline to follow-up visit with regression testing the effects of demographics and respiratory diagnoses

		ΔzFEV$_1$ ($n=698$)		ΔzFVC ($n=698$)		ΔzFEV$_1$/FVC% ($n=698$)		ΔzD_{LCO} ($n=253$)	
		Mean Δ (95%CI)	*p*	Mean Δ (95%CI)	*p*	Mean Δ (95%CI)	*p*	Mean Δ (95%CI)	*p*
Paired sample *t* test		0.15 (0.10, 0.26)	< 0.01	0.25 (0.20, 0.31)	< 0.01	− 0.10 (− 0.17, − 0.03)	< 0.01	0.08 (− 0.05, 0.21)	0.22
Regression		β (95%CI)	*p*	β (95%CI)	*p*	β (95%CI)	*p*	β (95%CI)	*P*
Age (10 years)		− 0.01 (− 0.05, 0.04)	0.75	− 0.01 (− 0.05, 0.04)	0.84	− 0.01 (− 0.07, 0.05)	0.72	0.02 (− 0.10, 0.15)	0.69
Duration of Care# (1 year)		0.06 (0.04, 0.08)	< 0.01	0.06 (0.04, 0.08)	< 0.01	0.03 (0.01, 0.05)	0.01	0.04 (0.00, 0.08)	0.03
BMI*	Underweight	− 0.19 (− 0.43, 0.05)	0.12	− 0.38 (− 0.66, − 0.10)	< 0.01	0.23 (− 0.09, 0.55)	0.20	− 0.11 (− 0.80, 0.58)	0.76
	Normal	Reference	–	Reference	–	Reference	–	Reference	–
	Overweight	− 0.11 (− 0.27, 0.05)	0.18	− 0.16 (− 0.34, 0.02)	0.08	− 0.03 (− 0.24, 0.18)	0.83	0.09 (− 0.32, 0.51)	0.66
	Obese	− 0.14 (− 0.29, 0.01)	0.08	− 0.21 (− 0.38, − 0.03)	0.02	− 0.05 (− 0.25, 0.15)	0.65	0.00 (− 0.42, 0.43)	0.98
Sex	Female	0.02 (− 0.08, 0.13)	0.67	− 0.02 (− 0.14, 0.10)	0.74	0.00 (− 0.14, 0.14)	1.00	0.08 (− 0.19, 0.36)	0.55
First Nations		− 0.05 (− 0.16, 0.07)	0.42	0.05 (− 0.08, 0.18)	0.46	− 0.17 (− 0.32, − 0.02)	0.03	0.10 (− 0.20, 0.40)	0.52
Smoking	Current	− 0.10 (− 0.25, 0.05)	0.20	− 0.13 (− 0.30, 0.04)	0.14	0.02 (− 0.18, 0.21)	0.85	− 0.31 (− 0.73, 0.11)	0.15
	Former	− 0.04 (− 0.18, 0.10)	0.58	− 0.09 (− 0.25, 0.07)	0.25	0.09 (− 0.09, 0.27)	0.34	− 0.46 (− 0.85, − 0.07)	0.02
	Never	Reference	–	Reference	–	Reference	–	Reference	–
Household smoke		0.06 (− 0.05, 0.17)	0.30	0.03 (− 0.10, 0.15)	0.66	0.05 (− 0.09, 0.20)	0.48	− 0.27 (− 0.55, 0.02)	0.07
Asthma ($n=262$)		0.05 (− 0.07, 0.17)	0.40	0.08 (− 0.05, 0.22)	0.20	0.14 (− 0.01, 0.29)	0.07	0.10 (− 0.22, 0.43)	0.52
COPD ($n=299$)		− 0.13 (− 0.26, − 0.01)	0.04	− 0.06 (− 0.21, 0.08)	0.38	− 0.13 (− 0.29, 0.03)	0.12	0.07 (− 0.25, 0.37)	0.68
OSA ($n=195$)		− 0.05 (− 0.18, 0.07)	0.42	− 0.05 (− 0.19, 0.10)	0.50	0.01 (− 0.15, 0.18)	0.88	0.20 (− 0.13, 0.54)	0.23
Bronchiectasis ($n=42$)		0.13 (− 0.08, 0.35)	0.22	0.35 (− 0.01, 0.72)	0.26	0.16 (− 0.12, 0.44)	0.68	0.22 (− 0.36, 0.79)	0.46
Pulm htn ($n=18$)		0.28 (− 0.04, 0.60)	0.08	0.36 (− 0.02, 0.75)	0.07	− 0.02 (− 0.46, 0.42)	0.93	0.21 (− 0.92, 0.50)	0.57

#Duration of care from baseline to best follow-up visit occurring within last 12 months of care. *BMI categories: Underweight (< 18.5 kg/m^2), Normal (18.5–24.9 kg/m^2), Overweight (25–29.9 kg/m^2), Obese (≥ 30 kg/m^2). Regression model adjusted for patient age and length of care. Abbreviations: COPD, chronic obstructive pulmonary disease. OSA, obstructive sleep apnoea. Pulm htn, pulmonary hypertension

Australians [3], it is promising that lung function decline associated with chronic respiratory disease appears to have been somewhat halted through specialist care at IROC. We do, however, interpret these changes with caution, and several study limitations should be considered.

We cannot be certain that these improvements to FEV_1 and FVC parameters may not be, in part, secondary to a learning effect through repetition and improvement in technique over repeated clinic visits. Whilst all lung function testing was performed by experienced respiratory scientists, these results are clinically reported values and a minority may not meet full ATS/ERS criteria [11, 12]. We also cannot discount the influence of survivorship bias, as there were a significant number of patients who were lost to follow-up (Supplement Table S1) for many reasons including those previously mentioned, such as discharge of healthy patients back to primary care, and high First Nations mobility. Without analysis and reporting of patient outcomes, we cannot measure the influence of these effects. Further, whilst the "Other/mixed" GLI 2012 spirometry reference set has been found to be appropriate for use in First Nations children and young adults (3–25 years), no such reference set validation has been done for spirometry or gas diffusion testing in First Nations adults. Finally, our data include First Nations adults seen in regional and remote Queensland only. Additional data from other Australian regions are needed to confirm the generalisability of our findings.

Our study has highlighted the demographics and lung function of adults seen at specialist respiratory outreach clinics in regional and remote Queensland. When compared to similar studies of respiratory outreach services within the NT, adults (including First Nations) seen at IROC had significantly better lung function even at baseline. We determined that patients who are underweight, smoke, are exposed to second-hand household smoking, and who are assigned a respiratory diagnosis have significantly poorer lung function. In the 40% of patients seen in which follow-up lung function had been performed, FEV_1 and FVC significantly improved, FEV_1/FVC% reduced significantly, whilst D_{LCO} was unchanged. Given the nature of chronic respiratory diseases present in this population, we suggest that providing culture-appropriate services for adults with respiratory illness may halt the decline in lung function typically seen when diseases such as COPD and bronchiectasis are suboptimally managed.

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Declarations

Conflict of interest All authors declare that they have no conflict of interest.

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