An observational study of *Pseudomonas aeruginosa* in adult long-term ventilation

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Shareable abstract (@ERSpublications)
Pseudomonas aeruginosa isolation is common (17%) in long-term ventilated adults and significantly associated with tracheostomy, cystic fibrosis and bronchiectasis. Tracheostomy patients with *P. aeruginosa* isolates culture copathogens more frequently. https://bit.ly/3vvxBbB

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Abstract

Introduction *Pseudomonas aeruginosa* increases morbidity and mortality in respiratory disease. To date the long-term ventilation population does not have clear guidelines regarding its management.

Method We undertook a retrospective observational study in a regional long-term ventilation population (837 patients). We defined the primary outcome as *P. aeruginosa* isolation. In addition positive cultures for copathogens (*Serratia*, *Proteus* species, *Stenotrophomonas*, *Burkholderia cepacia* complex and nontuberculous mycobacteria) were recorded. Logistic regression and odds ratios were calculated.

Results 17.6% of the cohort isolated *P. aeruginosa*, and this pathogen was cultured more frequently in patients with a tracheostomy (logistic regression coefficient 2.90, $p \leqslant 0.0001$) and cystic fibrosis/bronchiectasis (logistic regression coefficient 2.48, $p \leqslant 0.0001$). 6.3% of patients were ventilated *via* tracheostomy. In the *P. aeruginosa* positive cohort 46.9% of patients were treated with a long-term macrolide, 36.7% received a nebulised antibiotic and 21.1% received both. Tracheostomised *P. aeruginosa* positive patients received a nebulised antibiotic more frequently (OR 2.63, 95% CI 1.23–5.64, p=0.013). Copathogens were isolated in 33.3% of the *P. aeruginosa* cohort. In this cohort patients with a tracheostomy grew a copathogen more frequently than those without (OR 2.75, 95% CI 1.28–5.90).

Conclusions *P. aeruginosa* isolation is common within the adult long-term ventilation population and is significantly associated with tracheostomy, cystic fibrosis and bronchiectasis. Further research and international guidelines are needed to establish the prognostic impact of *P. aeruginosa* and to guide on antimicrobial management. The increased risk of *P. aeruginosa* should be considered when contemplating long-term ventilation *via* tracheostomy.

Introduction

Pseudomonas aeruginosa (*Pa*) is a well-recognised opportunistic Gram-negative respiratory pathogen affecting a number of patient groups with underlying respiratory diseases. These include patients with COPD, bronchiectasis and cystic fibrosis (CF). It drives both morbidity [1] and early mortality [2] in the latter two diseases leading to guideline recommendations to conduct surveillance for detecting this pathogen [3, 4]. Additionally guidelines recommend the use of either systemic (*e.g.* long-term macrolides) or pulmonary-targeted antibiotic therapies (*e.g.* nebulised antibiotics) to reduce exacerbation rates [3, 4].

Home long-term ventilation (LTV) services have a diverse range of aetiologies under their care. Common indications include congenital muscular dystrophies such as Duchenne muscular dystrophy (DMD), acquired neuromuscular disorders such as motor neurone disease (MND), restrictive chest wall conditions such as kyphoscoliosis, diaphragm palsy, sleep disordered breathing, obesity hypoventilation syndrome (OHS) and respiratory diseases such as those documented above.

In acute illness, when invasive ventilation is required, there is an increased risk of *Pa* infection, *i.e.* ventilator-associated pneumonia, and data for patients chronically invasively ventilated in a home care setting suggest *Pa* is common within a year of discharge [5].

Improving survival rates on LTV (both invasive and noninvasive), has resulted in increasingly complex patients being managed by LTV services. These patients are managed by specialist centres. However, there is minimal literature on the burden of *Pa* in those requiring home LTV. In the absence of guidelines on managing this infection outside of CF and bronchiectasis [3, 4] we sought to describe both the prevalence of *Pa* in our home ventilation cohort and the management strategies applied.

Material and methods

Study population

We undertook a retrospective observational study on a regional LTV population. The service covers the North East and Cumbria, with a population of 3 million. It is the primary care provider for LTV patients in the region and receives referrals from 11 hospitals. Three satellite clinics are required.

The population of patients was identified using the regional LTV database. At the time of access (March 2021) the database consisted of 837 active adult patients. LTV care was defined as receiving noninvasive ventilation (NIV), mechanical insufflation–exsufflation (MI-E), both treatments or high-flow nasal cannula. The database contained the indication for LTV.

Data collection

Electronic medical records at our hospital and referring units were accessed to record the additional information: *Pa* cultured ever, *Pa* cultured in the last 2 years, *Pa* treated with a nebulised antibiotic or a long-term macrolide, presence of tracheostomy for ventilation, requirement for long-term oxygen therapy (LTOT) or ambulatory oxygen therapy (AOT), and prescription of the mucolytic carbocisteine.

Patients were grouped according to individual diagnosis or categories as follows: airway disease (asthma/COPD), CF/bronchiectasis, interstitial lung diseases, restrictive chest wall conditions, diaphragm palsy, OHS and obstructive sleep apnoea (OSA), MND, DMD, all other neuromuscular disease (*e.g.* myopathies and dystrophies), cerebral palsy, spinal cord injury, other neurological conditions and other (*i.e.* miscellaneous) (see supplementary appendix 1). Patients with COPD–OSA overlap were included within the airway disease category.

We defined the primary outcome as *Pa* colonisation, identified through historical or current respiratory culture results. In view of the common inherent resistance of certain bacterial species to colistin (colistimethate sodium) we also recorded any present or historically positive cultures for *Serratia*, *Proteus* species, *Stenotrophomonas*, *Burkholderia cepacia* complex and nontuberculous mycobacteria (NTM).

Data analysis

We described observed frequencies and compared distributions using odds ratios. A logistic regression was performed (Mathematica, Version 12.3.1; Wolfram Research Inc., Champaign, IL, USA (2021)) to determine the independent effects of disease type and the presence/absence of tracheostomy on *Pa* isolates.

Results

We identified 837 patients under the regional LTV service and accessed present and historical microbiology results for all of them. 6.3% were ventilated *via* tracheostomy. 17.6% were culture positive for *Pa* (from airway samples: sputum, tracheal aspirates, bronchial lavage) and 8.6% culture positive within the last 24 months. Within the *Pa* positive cohort the mean age was 52 years with male:female ratio 1.88:1, reflecting the male dominant disease pattern of several LTV conditions. At time of data gathering (March 2021) patients had received ventilation for a mean of 1828 days (5 years). 36.1% of *Pa* positive patients were on both LTV and MI-E, 18.4% solely on MI-E and 6.8% used a lung volume recruitment bag in addition to LTV. Two patients received ventilation *via* high-flow nasal cannula.

Patients with CF and patients with tracheostomy had the highest prevalence of *Pa* colonisation (74.2% and 71.7% respectively). Spinal cord injury and the grouping “other” (*e.g.* ventilatory failure of unknown origin, global developmental delay, *etc.*) had the highest numbers of tracheostomy patients. Patients with primary respiratory diseases (COPD, asthma, bronchiectasis, CF) did not require tracheostomy. 33.3% of patients using an MI-E device had positive *Pa* isolates.

Demographic and clinical data are described in table 1, including the prevalence of *Pa* by diagnostic subgroup, and by tracheostomy. The prevalence of *Pa* in patients with CF/bronchiectasis was high, as expected (74.2%); however, there was also a high burden of disease in patients with spinal cord injuries (40.0%), other (33.3%), cerebral palsy (31.6%) and DMD (26.9%).

Logistic regression (LR) was performed to account for the confounding variables created by tracheostomy and disease group (see table 2). This identified tracheostomy as being the strongest positive factor associated with *Pa* (LR coefficient 2.90, p⩽0.0001). Patients with CF/bronchiectasis also had a positive association (LR coefficient 2.48, p⩽0.0001). Patients with cerebral palsy had a non-significant but positive coefficient (LR coefficient 0.65, p=0.302). In contrast, MND and OHS/OSA were negatively associated with the presence of *Pa* culture (LR coefficient −2.14, p=0.004, and −1.83, p=0.001, respectively).

TABLE 1 Clinical data

Patient group	Number of patients	Tracheostomy %	*Pa* positive n (%)
Total patients	837		147 (17.6)
Tracheostomy	53		38 (71.7)
Without tracheostomy	784		109 (13.9)
1. Respiratory conditions	256	0.0	59 (23.1)
Tracheostomy	0		0 (0)
Without tracheostomy	256		59 (23.1)
a) Airway disease	220	0.0	35 (15.9)
b) CF and bronchiectasis	31	0.0	23 (74.2)
c) Interstitial lung diseases	5	0.0	1 (20)
2. Restrictive chest wall conditions	54	1.9	5 (9.3)
Tracheostomy	1		1 (100)
Without tracheostomy	53		4 (7.4)
3. Diaphragm palsy	21	4.8	1 (4.8)
Tracheostomy	1		1 (100)
Without tracheostomy	20		0 (0)
4. OHS and OSA	162	0.0	6 (3.7)
Tracheostomy	0		0 (0)
Without tracheostomy	162		6 (3.7)
5. Neuromuscular and neurological conditions	329	14.3	71 (21.6)
Tracheostomy	47		32 (68.1)
Without tracheostomy	282		39 (13.8)
a) MND	53	9.4	3 (5.7)
Tracheostomy	5		2 (40)
Without tracheostomy	48		1 (2.1)
b) DMD	26	15.4	7 (26.9)
Tracheostomy	4		3 (75)
Without tracheostomy	22		4 (18.2)
c) All other neuromuscular disease	111	9.0	17 (15.3)
Tracheostomy	10		8 (80)
Without tracheostomy	101		9 (8.9)
d) Cerebral palsy	19	0.0	6 (31.6)
Tracheostomy	0		0 (0)
Without tracheostomy	19		6 (31.6)
e) Spinal cord injury	45	33.3	18 (40)
Tracheostomy	15		10 (66.7)
Without tracheostomy	30		8 (26.7)
f) Other neurological conditions	75	17.3	20 (26.7)
Tracheostomy	13		9 (69.2)
Without tracheostomy	62		11 (17.7)
6. Other	15	26.7	5 (33.3)
Tracheostomy	4		4 (100)
Without tracheostomy	11		1 (9.1)

Pa: *Pseudomonas aeruginosa*; CF: cystic fibrosis; OHS: obesity hypoventilation syndrome; OSA: obstructive sleep apnoea; MND: motor neurone disease; DMD: Duchenne muscular dystrophy.

TABLE 2 Logistic regression

Patient group	Number of patients	Coefficient	p-value
Total patients	837		
Tracheostomy	53	2.90	<0.0001
1. Respiratory conditions	256		
a) Airway disease	220	−0.24	0.589
b) CF and bronchiectasis	31	2.48	<0.0001
c) Interstitial lung diseases	5	0.04	0.972
2. Restrictive chest wall conditions	54	−0.98	0.117
3. Diaphragm palsy	21	−2.00	0.083
4. OHS and OSA	162	−1.83	0.001
5. Neuromuscular and neurological conditions	329		
a) MND	53	−2.14	0.004
b) DMD	26	−0.13	0.840
c) All other neuromuscular disease	111	−0.75	
d) Cerebral palsy	19	0.65	0.302
e) Spinal cord injury	45	–	–
f) Other neurological conditions	75	−0.23	0.121
6. Other	15	−0.17	0.828

CF: cystic fibrosis; OHS: obesity hypoventilation syndrome; OSA: obstructive sleep apnoea; MND: motor neurone disease; DMD: Duchenne muscular dystrophy.

Isolates of copathogens

Commencement of a nebulised antibiotic had limited documentation, which hindered assessment of *Pa* suppression or effects on emerging pathogens. *Serratia*, *Proteus* species, *Stenotrophomonas*, *Burkholderia cepacia* complex and NTM were isolated in 8.5% of the LTV cohort and 33.3% of the *Pa* cohort. In the *Pa* cohort the copathogens cultured most frequently were *Serratia* (15.0%) and *Stenotrophomonas* (11.6%). Culture of copathogens was more frequent in patients colonised with *Pa* (OR 15.18, 95% CI 8.80–26.21, p⩽0.0001) (see table 3).

TABLE 3 Culture positive for copathogens

Patient group	Number of patients	*Pa* positive n	Proportion of *Pa* with copathogen %
***Serratia, Proteus* species, *Stenotrophomonas*, *Burkholderia cepacia* complex and NTM isolates**	71	49	33.3
Tracheostomy	21	19	
Without tracheostomy	50	30	
a) *Serratia* isolates	31	22	15.0
Tracheostomy	13	11	
Without tracheostomy	18	11	
b) *Proteus* spp. isolates	17	12	8.2
Tracheostomy	7	7	
Without tracheostomy	10	5	
c) *Stenotrophomonas* isolates	21	17	11.6
Tracheostomy	4	4	
Without tracheostomy	17	13	
d) *Burkholderia cepacia* isolates	2	2	0.1
Tracheostomy	0	0	0
Without tracheostomy	2	2	
e) NTM isolates	6	5	3.4
Tracheostomy	0	0	
Without tracheostomy	6	5	

Pa: *Pseudomonas aeruginosa*; NTM: nontuberculous mycobacteria.

The proportion of patients with one or more positive copathogen was highest in the patient groups CF/bronchiectasis (35.5%) and spinal cord injury (28.9%). Logistic regression to account for tracheostomy bias was not performed due to small sample size. However, there were no tracheostomy patients in the CF/bronchiectasis grouping but six in the spinal cord injury group.

52.7% of patients treated with a nebulised antibiotic grew copathogens.

Management and treatment patterns

In the *Pa* cohort 46.9% of patients received a long-term macrolide and 36.7% received a nebulised antibiotic. 21.1% patients received both a nebulised antibiotic and a long-term macrolide.

Azithromycin was prescribed in 18.5% of total patients and 46.9% of the *Pa* cohort. *Pa* colonisation was more common in patients prescribed azithromycin (OR 6.21, 95% CI 4.19–9.22, p⩽0.0001).

36.7% of the *Pa* positive cohort were treated with a nebulised antibiotic. Colistin was the most frequently prescribed antibiotic (85.2%) (see figure 1).

In the tracheostomised *Pa* positive cohort, patients received a nebulised antibiotic more frequently (OR 2.63, 95% CI 1.23–5.64, p=0.013), and were colonised with a copathogen more often (OR 2.75, 95% CI 1.28–5.90, p=0.01) than *Pa* positive patients without a tracheostomy. Fewer patients in this group received azithromycin, but this difference was not significant (OR 0.61, 95% CI 0.28–1.30, p=0.202) (see table 4).

21.5% of all patients received LTOT and/or AOT, while in the *Pa* positive cohort 30.6% of patients received LTOT and/or AOT. *Pa* colonisation was more common in patients with LTOT and/or AOT (OR 1.84, 95% CI 1.23–2.73, p=0.003).

Carbocisteine was prescribed in 27.6% of total patients and 51.7% of the *Pa* positive cohort. *Pa* colonisation was more common in patients prescribed carbocisteine (OR 3.69, 95% CI 2.55–5.35, p<0.0001) (see table 5).

Discussion

Pseudomonas aeruginosa is a ubiquitous organism found in the natural environment but is frequently associated with both acute and chronic infections of the respiratory tract [6]. Recent paediatric research

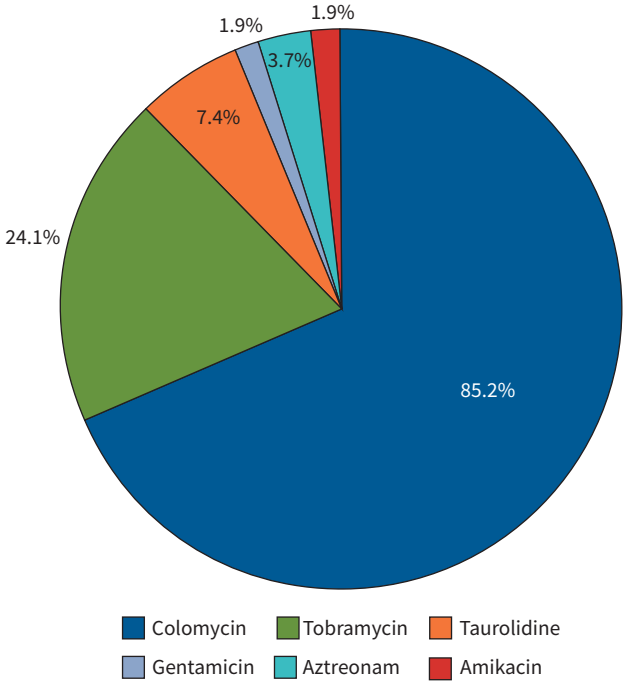

FIGURE 1 Nebulised antibiotic prescribed.

TABLE 4 *Pa* culture positive group

Pa positive culture	Number of patients	Treated n (%)	95% CI	OR	95% CI	p-value
Long-term macrolide: azithromycin						
Without tracheostomy	110	55 (50.0)	40.3–59.7			
Tracheostomy	37	14 (37.8)	22.5–55.2	0.61	0.28–1.30	0.202
Nebulised antibiotics						
Without tracheostomy	110	34 (30.9)	22.5–40.4			
Tracheostomy	37	20 (54.1)	36.9–70.5	2.63	1.23–5.64	0.013
Culture positive for copathogen						
Without tracheostomy	110	33 (30)	21.6–39.5			
Tracheostomy	37	20 (54.1)	36.9–70.5	2.75	1.28–5.90	0.010

Pa: *Pseudomonas aeruginosa*.

suggested a 15% prevalence of *Pa* in children with complex neuromuscular disorders and cerebral palsy [7]. The pathogen colonised 11% of a paediatric LTV cohort and reached a prevalence of 63% in LTV paediatric patients with a tracheostomy [7].

The current study is, to our knowledge, the first extensive work on *Pa* isolates in an adult LTV cohort. Our key findings are that *Pa* colonisation is frequent in adults on LTV, affecting nearly 1 in 5 (17.6%). Consistent with previous data [7], we found that tracheostomy is a significant factor influencing *Pa* positive culture. Patients with CF and bronchiectasis also had high *Pa* culture rates, an expected result as this pathogen is associated with these diseases. It is therefore expected to be intensified in a population with high disease severity requiring LTV [2]. Lastly, patients with a tracheostomy who were colonised with *Pa* were more likely to receive treatment in the form of a nebulised antibiotic and have samples positive for copathogens (*Serratia*, *Proteus* species, *Stenotrophomonas*, *Burkholderia cepacia* complex and NTM).

The frequency of *Pa* in the tracheostomy population was 71.7%, a higher rate than documented in previous paediatric studies [7]. Consistent with previous data [7], we also observed high rates of *Pa* in the cohort with cerebral palsy, but these results were not significant. This likely reflects the small sample size in this group (19). Interestingly no patients with cerebral palsy had a tracheostomy.

Patients with OSA/OHS and MND were associated with a statistically significantly lower probability of culturing *Pa* isolates. This outcome is not unexpected. LTV for OHS is associated with a reduced mortality (5-year survival 77.3%) than in untreated OHS [8]. High NIV adherence results in less hospital admission, and improved mortality [9]. We postulate that due to the rapid progression and reduced life expectancy in MND, the time period on LTV may be short, with lower lifetime antibiotic exposure and less time for acquisition of *Pa*. Further research into the reduced frequency of *Pa* in these disease categories is welcomed.

LTV services care for a diverse number of aetiologies. Since tracheostomy is associated with increased rates of *Pa*, a useful tool for home ventilation clinicians is to understand which disease categories have higher rates of tracheostomy. We found patients with spinal cord injury had the highest prevalence of tracheostomy, followed by the groups “other” and DMD.

TABLE 5 Other management

	Number of patients (n)	*Pa* positive n (%)	95% CI	OR	95% CI	p-value
No LTOT and/or AOT	657	101 (15.4)	12.7–18.4			
LTOT and/or AOT	180	45 (25.0)	17.9–30.5	1.84	1.23–2.73	0.003
No long-term macrolide: azithromycin	682	78 (11.4)	9.2–14.1			
Long-term macrolide: azithromycin	155	69 (44.5)	36.5–52.7	6.21	4.19–9.22	<0.0001
No mucolytic: carbocisteine	606	71 (11.7)	9.3–14.6			
Mucolytic: carbocisteine	231	76 (32.9)	26.9–39.4	3.69	2.55–5.35	<0.0001

Pa: *Pseudomonas aeruginosa*; LTOT: long-term oxygen therapy; AOT: ambulatory oxygen therapy.

Nearly half of *Pa* positive patients received treatment in the form of a long-term macrolide, and over a third received a nebulised antibiotic. Macrolide and nebulised antibiotic use are recommended in guidelines for preventing *Pa*-associated respiratory exacerbations for both bronchiectasis and CF. These agents are not specifically recommended in neuromuscular disease guidelines, and hence treatment is often empirical [10, 11]. There is a potential for these modalities to cause harm; colistin has been associated with respiratory arrest in myasthenia gravis [12] but also potential benefit, *i.e.* reducing/preventing *Pa* infections [12]. The clinical rationale for commencing antibiotic treatment in our cohort was not analysed, nor was exacerbation rate secondary to *Pa* infection, or the prevalence of *Pa*-associated pneumonia. A recent paediatric series [7] showed there was no immediate treatment benefit to acute anti-pseudomonals *versus* empirical antibiotics, highlighting the need for further research and understanding in this area.

There has been limited research regarding the prognostic significance of *Pa* in those with long-term tracheostomies [13, 14]. *Pa* has been shown to colonise tracheostomy tubes, forming biofilms [15]. Biofilms are recognised to cause an inherent resistance to antimicrobial treatment as well as bacterial persistence [7, 15]. Furthermore there is evidence of transmission to the lower airways resulting in complications such as pneumonia [16, 17]. As there are no clear guidelines for the management of *Pa* in long-term tracheostomy, treatment is guided by the patient's clinical presentation and physicians' acumen. In the acute ventilation setting there is a tendency to treat, reflecting the critical illness of these patients and the priority to prevent ventilator-associated pneumonia. We recorded a significant increase in treatment with a nebulised antibiotic in our *Pa* tracheostomy population (54.1%) but are unable to conclude whether this was guided by patients' clinical deterioration/biochemical markers or solely triggered by the presence of tracheostomy. Another important variable to consider is sampling bias, and that tracheostomised patients may have sputum cultures sent more frequently as part of secretion management or for intentional surveillance.

There was a wide range in treatment modalities used in the management of these patients. This included combinations of and isolated use of long-term macrolides, nebulised colistin, nebulised aminoglycosides, cyclical nebulised antibiotic, *e.g.* tobramycin/colistin, and widespread use of carbocisteine as a mucolytic agent. It is important to recognise that prescription does not reflect adherence to treatment. Adherence to long-term nebulised antibiotic therapy can be challenging, and patients requiring LTV already have a significant treatment burden.

Within the *Pa* isolate cohort requirement for LTOT and/or AOT was not independent of diagnostic group. 80% of patients on LTOT and/or AOT had a respiratory diagnosis.

The exact date of commencement of a nebulised antibiotic had limited documentation, which hindered assessment of *Pa* suppression or effects on emerging pathogens. Similarly the COVID-19 pandemic has limited sputum sample collections as clinics carried out more remote consultations in 2020–2021. Within the cohort of *Pa* positive isolates, we had hoped to record the infective exacerbation rate pre- and post-treatment with *Pa* eradication antimicrobials. However, a key limitation to our study, reflecting the retrospective design, was the lack of documentation of this.

We found that *Serratia*, *Proteus* species, *Stenotrophomonas*, *Burkholderia cepacia* complex or NTM were isolated in 33.3% of the *Pa* cohort, and patients with a tracheostomy and *Pa* isolates were at increased risk of culturing a copathogen. This reflects the known association between tracheostomy and bacterial colonisation. A limitation to this research is we did not record the time period between isolating *Pa* and the copathogen. We recognise that the two isolates may have a significant time period between them. It is also possible the copathogen predates the first *Pa* isolate. NTM prevalence may be underestimated as growth requires rapid-growing mycobacteria medium to be specifically requested. The regional nature of the study resulted in samples being accessed across multiple sites and microbiology laboratories. These naturally will have slight variation in their approach to sample preparation.

An important question requiring further assessment is whether long-term antibiotics in LTV and LTV tracheostomy results in increased rates of virulent copathogens (*i.e.* multiple drug-resistant bacteria). Secondly, do long-term antimicrobials suppress *Pa* and/or exacerbation rates in this cohort? This is a point of major interest for the home ventilation community and also for antibiotic stewardship. It is important to balance treating infection against the potential future harm from antibiotic resistance.

The strengths of this study are the large sample size, data collection across multiple organisations and the description of treatment modalities applied. There are, however, limitations that need to be recognised, predominantly related to the retrospective design. Firstly, we cannot conclude that the prevalence described

here is truly representative – if a sample has not been requested as part of routine clinical assessment, we cannot confirm the absence of *Pa*. Secondly, from the data gathered we do not know what proportion of *Pa* isolates represent asymptomatic colonisation *versus* a pathogen driving clinical deterioration. However, a degree of pragmatism is required when studying patients receiving LTV, acknowledging the reduced life expectancy seen in some subgroups which can make prospective study design challenging. Thirdly, although this was a regional study, we still encountered multiple aetiologies with small (n=1) cohorts (see supplementary material). This reflects the diversity of aetiologies managed by LTV services. In order to overcome this barrier a multicentre approach to data collection would be required. Additionally, we acknowledge that a valued piece of data would be the time period on LTV and/or tracheostomy to the first isolate of *Pa*. Lastly, although infrequent, our service has patients who require home ventilation following a failed wean and level 3 intensive care. In the immediate period following discharge these patients may be colonised with hospital acquired bacteria. However, the mean number of days before the first episode of ventilator-associated pneumonia in home ventilation is 345 days suggesting a complex relationship between culture status and major infection episodes [5].

We conclude that *Pa* positive culture is common within the adult LTV population and is significantly associated with the presence of tracheostomy. This is an important consideration, adding to the high rates of healthcare burden already seen in this population [18] Patients managed with LTV, particularly those with a tracheostomy, should be considered for surveillance sputum culture as is already applied in other at-risk groups such as bronchiectasis. Research is required into whether *Pa* isolated in the adult LTV population drives morbidity and/or mortality, as seen in other diseases such as COPD and bronchiectasis [1, 2, 19]. This evidence will help formulate international guidelines on long-term antimicrobial management. Finally, when considering whether to proceed with tracheostomy in a LTV setting, the higher risk of *Pa* isolates and attendant treatment burden (*i.e.* limited oral or enteral antibiotic choices) should be discussed during multidisciplinary team meetings and shared decision making with the patient.

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