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ACPRC

Original articles

Protocol

ACPRC editor foreword

We are delighted to bring you volume 54, issue 3 for the *Journal of the Association of Chartered Physiotherapists in Respiratory care*.

The volume starts with Stefania Spiliopoulou who reports on an observational evaluation of intensive care rehabilitation outcomes in COVID-19 compared to other respiratory viruses. King et al then presents a single centre, retrospective valuation on the rapid adoption of the ICS/FICM guidance for prone positioning in adult critical care with mechanically ventilated patients. The third article is by Mansell et al and is an evaluation of observational outcomes of patients with COVID-19 who received a tracheostomy during the first pandemic surge. Bass et al then present a randomised controlled trail to investigate if an online exercise platform is an acceptable tool to promote exercise participation in adults with cystic fibrosis. Following this, Banks et al report on a service evaluation on home monitoring and self-management for adult patients with cystic fibrosis during the COVID-19 pandemic. Tom Walker reports on an evaluation on the attendance and completion of cardiac rehabilitation following heart transplantation, and Drover et al report on their findings from a survey exploring the incidence of chest infection in wind musicians.

As part of the *Therapies in Critical Care Workforce Project*, Twose et al present a scoping review on the role and staffing in critical care. The volume also includes a further output from the ACPRC editorial board, led by Dr. Una Jones. The editorial board is tasked with leading the scoping, commissioning, co-ordination, and delivery of all new ACPRC guidance documents and resources and in this publication, Cork et al present a scoping review on airway clearance techniques for the intubated adult. The final article is a systematic review and thematic synthesis protocol on life after critical illness by King et al.

As always, we hope that you enjoy reading this issue of the ACPRC journal, and that you are inspired to write up and submit your work. We have now made a change to the submission process, with two submission windows per year closing on the 1st April and 1st November followed by two publications per year. Submission guidelines are available on the ACPRC website www.acprc.org.uk and are due to undergo some updates, so please review them prior to submitting to the journal. Please remember that we also provide members with support through the *Research Champion* and as editors we are very happy to discuss any potential article ideas with you too.

Kind regards

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Intensive care rehabilitation outcomes in COVID-19 compared to other respiratory viruses: an observational evaluation

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Keywords | COVID-19, influenza, rehabilitation, intensive care, physiotherapy.

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Abstract

Introduction

Estimating the rehabilitation trajectory of COVID-19 patients and other respiratory viruses (RVs), such as influenza, is essential for seasonal planning of intensive care unit (ICU) rehabilitation services in a post COVID-19 world. This service evaluation compares the differences in time taken to achieve rehabilitation milestones between mechanically ventilated patients in ICU with COVID-19 and other RVs.

Methods

A retrospective service evaluation was completed at two ICUs of an acute hospital trust. Adults admitted to ICU with a diagnosis of COVID-19, influenza, H1N1, coronavirus, metapneumovirus and respiratory syncytial virus were included. The review took place between March–June 2020 for COVID-19 patients and December 2016–February 2020 for other RVs. Rehabilitation milestones were measured in days taken to sit out of bed (SOOB), sit on the edge of the bed (SOEOB) and stand, including ICU mobility scale (IMS) on discharge.

Results

109 COVID-19 and 59 RV patients admitted to ICU were included. COVID-19 patients were ventilated for an additional four days ($p = 0.036$) and had a greater length of ICU stay by five days ($p = 0.194$). They also required an additional seven and four days to SOOB ($p = 0.043$) and stand ($p = 0.05$) respectively. The IMS for COVID-19 patients was five and RV patients scored 4 ($p = 0.061$).

Conclusions

COVID-19 results in patients requiring longer time-frames to achieve basic rehabilitation milestones when compared to other RVs, although a higher mobility level was achieved. ICU physiotherapy services require advanced planning of resources

and staffing during seasonal periods to account for the added pressure of COVID-19, which is expected to continue occupying ICU bedspaces despite the development of a vaccine.

Introduction

The COVID-19 pandemic has resulted in severe repercussions on rehabilitation services. Intensive care unit (ICU) rehabilitation teams have struggled to meet the demand of COVID-19 due to the sheer volume of cases during the pandemic, as well as their complexity (1). In the United Kingdom, COVID-19 patients were admitted to ICUs for a median of 10 days, where 72% required invasive mechanical ventilation (IMV) for a median of 13 days (2). Consequently, a high incidence of intensive care acquired weakness (ICU-AW) has been reported, whereby 52% of patients undergoing IMV continue to experience significant weakness when discharged from the ICU (3, 4). Therefore, it is not surprising that critically ill COVID-19 patients return home at a reduced level of physical functioning, needing mobility aids (49%) or long-term rehabilitation (14%) (5). Overall, the pandemic has highlighted the fundamental need for rehabilitation in order to promote quality of life after ICU in severe COVID-19 cases (6).

As we enter the post-pandemic era, there is concern that the co-existence of COVID-19 and other well-established respiratory viruses (RVs) will place extreme pressure on healthcare systems. Epidemiological studies show that RVs such as influenza and respiratory syncytial virus (RSV) are responsible for between 16% and 49% of ICU admissions with lower respiratory tract infections (7, 8). Influenza occupies a significant portion of ICU beds and already puts pressure on the delivery of rehabilitation services during the winter period, consequently shaping healthcare services particularly during these months (9). Despite sharing many similarities, studies show that COVID-19 places a greater burden on ICUs compared to influenza. COVID-19 patients spend an additional four and five days in ICU and hospital respectively, are mechanically ventilated for twice as along, and have almost double the risk of requiring intubation (2, 10). This increases the likelihood of developing ICU-AW, demanding considerably more capacity for the provision of rehabilitation services.

During the COVID-19 pandemic we have seen a dramatic decrease in the incidence of RVs in ICUs, likely due to new-normal social distancing measures and flu vaccinations (11). We can only expect that the existence of COVID-19 will further complicate the forthcoming influenza seasons (12), however there is a need to better estimate the additional pressures ICU rehabilitation services will face in the winter months. The aim of this evaluation is to present the differences between mechanically ventilated COVID-19 and other RV patients, within the context of ICU rehabilitation and the achievement of basic milestones. This will help ICU and therapy managers better prepare for the combined pressures of COVID-19 and RVs that will constitute the new reality of a post-pandemic winter.

Methods

Design

A service evaluation was completed at two general, adult ICUs of an acute hospital in the United Kingdom (Nottingham University Hospitals NHS Trust). Data was collected for patients admitted to ICU with any RV, including COVID-19, between 1st December 2016 and 30th June 2020. Data was collected from patients' medical and rehabilitation notes, as well as nursing charts. Patient anonymity was preserved by removing personal data and using a password protected database. Ethical approval was waived for this study as routine practice was not changed and patient confidentiality was maintained. This study was registered as a service evaluation within Nottingham University Hospitals NHS Trust (project ID number 20-598C).

Clinical setting

The extenuating circumstances of the pandemic called for significant structural changes within ICU services to accommodate the influx of COVID-19 admissions. Therefore, for this study, ICU was defined as any hospital space that provided specialist level two or three intensive care, including the use of operating theatre areas. During the pandemic, the ICU physiotherapy service hours were extended to a 12 hour 7-day service (8am–9pm), whereas previously this service would normally run between 8am–4pm, with one late-shift physiotherapist between 4pm–9pm. This change was possible due to staff redeployment from other physiotherapy specialties, increasing the capacity of the ICU physiotherapy team by approximately 40%. This was not the case for patients admitted with RVs before the COVID-19 pandemic, where rehabilitation services ran as normal.

Population

Adult patients admitted to ICU with COVID-19 and other RVs during the aforementioned time-frame were included in this study. More specifically, COVID-19 admissions were during March–June 2020, whereas other RV admissions were between December 2016 and February 2020. Other RVs included influenza (type A and B, H1N1), parainfluenza, human coronavirus, human metapneumovirus (HMPV) and RSV. Admissions for fungal or non-viral pneumonias and paediatric patients were excluded from this study.

Study variables

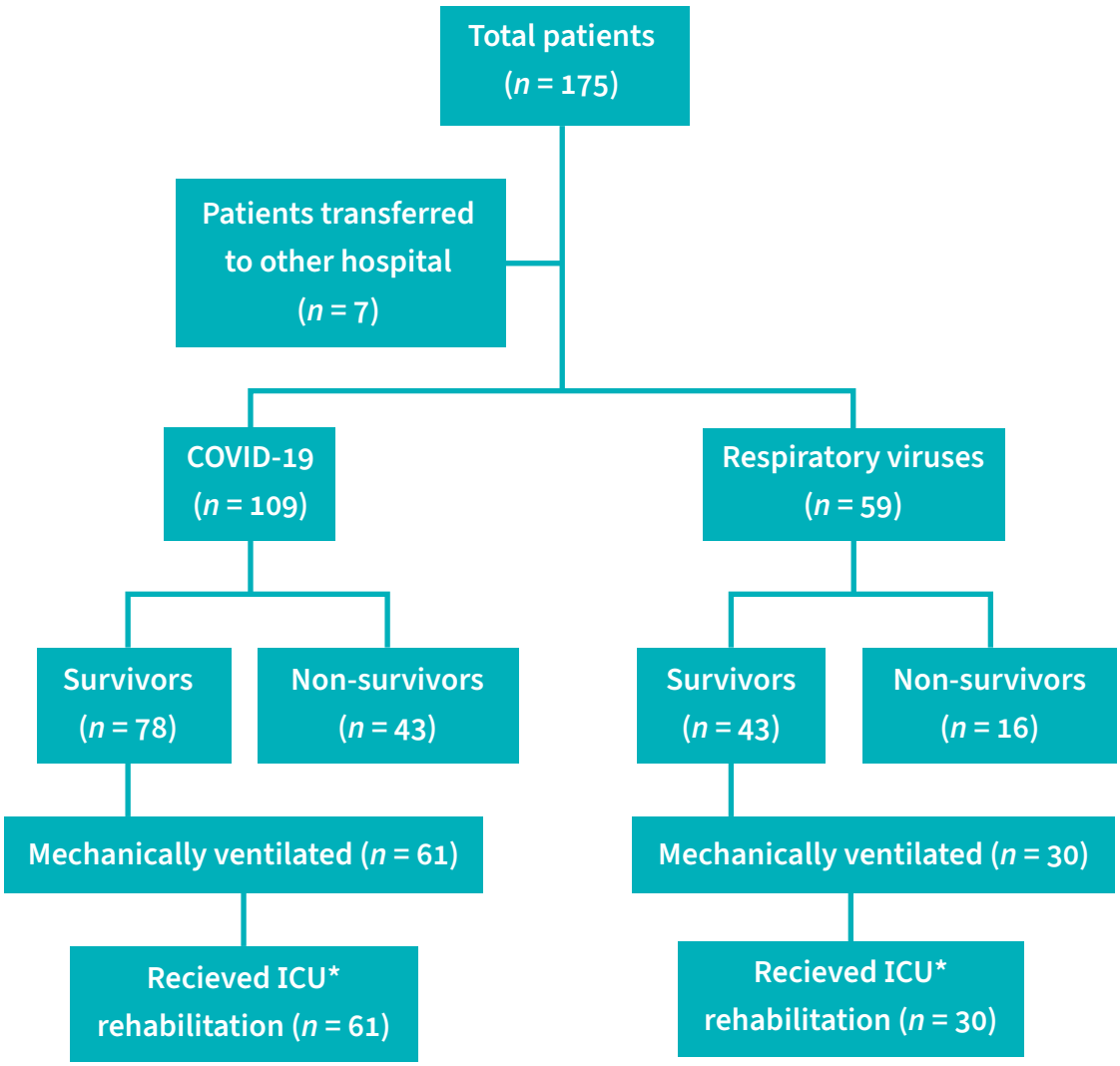
The rehabilitation variables studied were the number of days taken to achieve three rehabilitation milestones: sit on the edge of the bed (SOEOB), sit out of bed (SOOB) and stand. Level of mobility using the ICU mobility score (IMS) was collected at discharge from ICU. The number of physiotherapy sessions was also documented. Generic demographic data such as gender, age and comorbidities were collected. The independent variables included duration of ICU stay and the use of invasive or non-invasive ventilation, neuromuscular blockades (NMBAs), proning techniques, pre-oxygenation and tracheostomies.

Pre-oxygenation refers to the use of a higher fraction of inspired oxygen prior to any physiotherapy manoeuvre, in anticipation of significant oxygen desaturation.

Statistical analysis

Continuous variables are presented as means and standard deviations, whereas categorical variables are described as percentages. Chi-squared tests were used for categorical variables and Student's *t*-test for continuous variables, respecting the central limit theorem for sample sizes greater than 30 (13). A significance level of $p < 0.05$ was used. The analyses completed included:

1. Demographic data for COVID-19 and RVs.
2. Demographics for COVID-19 and RVs between survivors and non-survivors.
3. ICU outcomes and treatments for COVID-19 and RVs.
4. Rehabilitation outcomes for COVID-19 and RVs for mechanically ventilated ICU survivors.



*ICU = intensive care unit.

Figure 1: Flowchart of data collection.

Results

A total of 175 patients were studied, where seven were excluded due to transfer to other hospital centres (Figure 1).

109 COVID-19 patients (65%) and 59 RV patients (35%) were studied. The distribution of all viruses for this study's population is demonstrated in Figure 2.

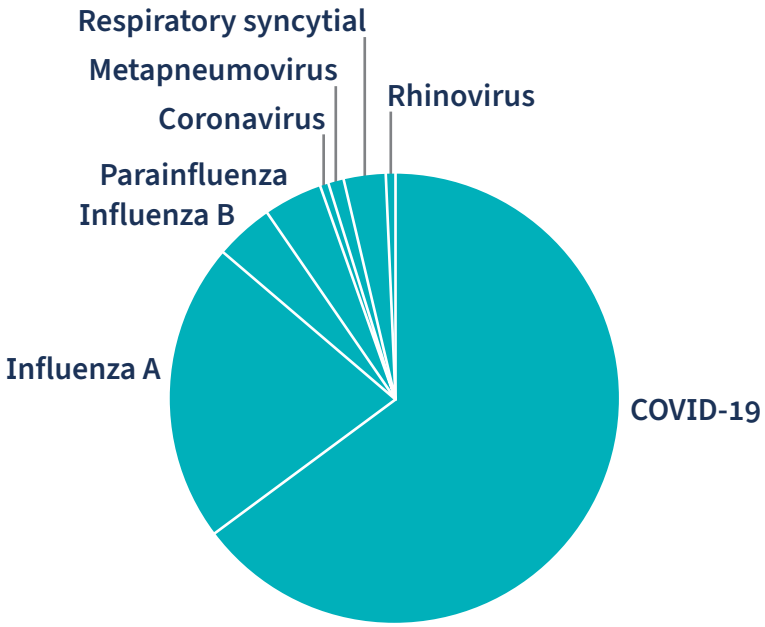


Figure 2: Distribution of respiratory viruses within study population (n = 168).

Fifteen percent more men were affected by COVID-19 compared to RVs (p = 0.054, Table 1). Common comorbidities shared between the two groups of viruses included hypertension, cardiovascular disease, musculoskeletal disorders and diabetes. The COVID-19 group had 16% more patients with raised body mass index (BMI) (p <0.001). A 12% increase in general respiratory conditions and chronic obstructive pulmonary disease (COPD) was observed in the RV group (p = 0.024, p = 0.007), as well as cancer (18%, p <0.001). RV patients with a history of cardiovascular disease and cancer had 18% (p = 0.054) and 34% (p = 0.019) more deaths in ICU respectively (Table 2).

Table 1: Demographic data between all COVID-19 and RV* patients (*n* = 168).

	COVID-19 (*n* = 109)	RV* (*n* = 59)	*p* value
Age	56 ± 13**	59 ± 14**	.661
Gender			
Female	37 (34%)	29 (49%)	.054
Male	72 (66%)	30 (51%)	
Comorbidities			
Hypertension	37 (34%)	12 (20%)	.064
Cardiovascular disease	20 (18%)	17 (29%)	.118
Musculoskeletal disorder	21 (19%)	10 (17%)	.712
Diabetes	18 (20%)	8 (14%)	.285
Gastrointestinal system	19 (17%)	8 (14%)	.514
Cancer	7 (6%)	14 (24%)	.001
Raised body mass index	25 (23%)	4 (7%)	.008
Chronic obstructive pulmonary disease	9 (8%)	12 (20%)	.024
Renal	16 (15%)	6 (10%)	.408
Asthma	18 (17%)	4 (7%)	.074
Respiratory	5 (5%)	10 (17%)	.007
Hormone	13 (12%)	5 (8%)	.490
Mental health	3 (3%)	10 (17%)	.001
Neurological disorder	7 (6%)	6 (10%)	.386
Other	7 (6%)	6 (10%)	.386
Number comorbidities			
< = 1	43 (39%)	22 (37%)	.784
>1	66 (61%)	37 (63%)	

All results are presented in percentages (%) unless otherwise specified, with *p* values derived from Chi-squared tests.

* = RV (respiratory viruses).

** = Mean with standard deviation.

Table 2: Demographic data between survivors and deceased COVID-19 and RV* patients in ICU.

	Survivors (*n* = 121)		Deceased (*n* = 47)		*p* value
	COVID-19 (*n* = 78)	RV* (*n* = 43)	COVID-19 (*n* = 31)	RV* (*n* = 16)	
Age	54 ± 13	57 ± 16	60 ± 13	64 ± 9	.661
Gender					
Female	26 (33%)	25 (58%)	11 (35%)	4 (25%)	.223
Male	52 (67%)	18 (42%)	20 (65%)	12 (75%)	
Comorbidities					
Hypertension	26 (33%)	8 (19%)	11 (35%)	4 (25%)	.625
Cardiovascular disease	12 (15%)	10 (23%)	8 (26%)	7 (44%)	.054
Musculoskeletal disorder	13 (17%)	8 (19%)	8 (26%)	2 (13%)	.556
Diabetes	16 (21%)	7 (16%)	6 (19%)	1 (6%)	.532
Gastrointestinal system	16 (21%)	7 (16%)	3 (10%)	1 (6%)	.096
Cancer	3 (4%)	7 (16%)	3 (10%)	7 (44%)	.019
Raised body mass index	19 (24%)	4 (9%)	6 (19%)	0 (0%)	.337
Chronic obstructive pulmonary disease	6 (8%)	8 (19%)	3 (10%)	4 (25%)	.559
Renal	11 (14%)	4 (9%)	5 (16%)	2 (13%)	.667
Asthma	12 (15%)	4 (9%)	6 (19%)	0 (0%)	.937
Respiratory	4 (5%)	7 (16%)	1 (3%)	3 (19%)	.906
Hormone	8 (10%)	4 (9%)	5 (16%)	1 (6%)	.592
Mental health	2 (3%)	7 (16%)	1 (3%)	3 (19%)	.815
Neurological disorder	4 (5%)	6 (14%)	3 (10%)	0 (0%)	.682
Other	5 (6%)	5 (12%)	2 (6%)	1 (6%)	.682
Number comorbidities					
< = 1	34 (44%)	15 (35%)	9 (29%)	6 (37%)	.261
>1	44 (56%)	28 (65%)	22 (71%)	10 (63%)	

All results are presented in percentages (%) unless otherwise specified, with *p* values derived from Chi-squared tests.

* = RV (respiratory viruses).

An additional 8% ($p = 0.337$) of COVID-19 patients required level three care compared to RV patients (Table 3). COVID-19 patients were ventilated for an additional four days ($p = 0.036$), with 12% more NMBA use ($p = 0.036$), 16% more proning and 35% more pre-oxygenation during physical manoeuvring ($p < 0.001$). Both groups had similar use of tracheostomies, which were performed at day 13 of ICU stay. The length of ICU stay was five days greater in COVID-19 patients than in the RV group ($p = 0.194$).

Table 3: ICU* outcomes and treatments used between COVID-19 and RV patients who survived ICU.**

	COVID-19 ($n = 78$)	RV** ($n = 43$)	p value
Level of care (on admission)			
Level 2	51 (65%)	28 (65%)	.353
Level 3	27 (35%)	15 (35%)	
Level of care			
Level 2	17 (22%)	13 (30%)	.337
Level 3	61 (78%)	30 (70%)	
Length of ICU* stay	17 [8–28]	12 [6–24]	.194
Mechanical ventilation			
Patients requiring level 3 care	$n = 61$	$n = 30$	
Days of IMV***	17 [8–28]	13 [8–25]	.036
Day extubated	9 [7–12]	8 [6–12]	.829
Day SBT****	13 [7–24]	14 [10–20]	.066
Day 24 hours ventilator free	22 [12–30]	16 [11–26]	.388
Tracheostomy	36/61 (59%)	16/30 (53%)	.361
Day tracheostomy insertion	13 [12–17]	13 [10–16]	.241
Day decannulated	32 [25–39]	34 [26–36]	.966
Other treatments			
Neuromuscular blockade	42/61 (69%)	17/30 (57%)	.036
Proning	20/61 (33%)	5/30 (17%)	.001
Pre oxygenation	38/61 (62%)	8/30 (27%)	.001

All results are presented in percentages or median with interquartile ranges, with p values derived from Chi-squared tests and Student t-test.

* = ICU (intensive care unit); ** = RV (respiratory viruses); *** = IMV (invasive mechanical ventilation); **** = SBT (spontaneous breathing trial).

For both groups, a similar number of ICU physiotherapy sessions were received ($p = 0.029$) and rehabilitation began at day two of ICU stay ($p = 0.496$; Table 4). COVID-19 patients required an additional seven, one and four days to SOOB, SOEOB and stand respectively ($p = 0.043$, $p = 0.614$, $p = 0.05$; Figure 3). The COVID-19 group achieved a greater level of mobility (IMS grade five, for example transfer from bed to chair) compared to the RV group ($p = 0.061$).

Table 4: Rehabilitation milestone achievement and level of mobility between mechanically ventilated COVID-19 and RV* patients who survived ICU admission.**

	COVID-19 ($n = 61$)	RV* ($n = 30$)	p value
Physiotherapy treatment			
ICU** day started (passive or active exercise)	2 [2–2]	2 [1–2]	.496
Number ICU** sessions	24 [13–36]	23 [14–34]	.029
Rehabilitation milestones			
Sit out of bed	19 [14–26]	12 [9–17]	.043
Sit on edge of bed	15 [11–20]	14 [9–18]	.614
Stand	19 [12–27]	15 [12–22]	.050
Level of mobility (IMS*)**			
	5 [4–7]*****	4 [4–5]*****	.061

All results are presented in median with interquartile ranges, with p values derived from Student t-test.

*RV (respiratory viruses).

**ICU (intensive care unit).

***IMS (Intensive care mobility scale).

****IMS 4 = standing.

*****IMS 5 = transfer from bed to chair by stepping.

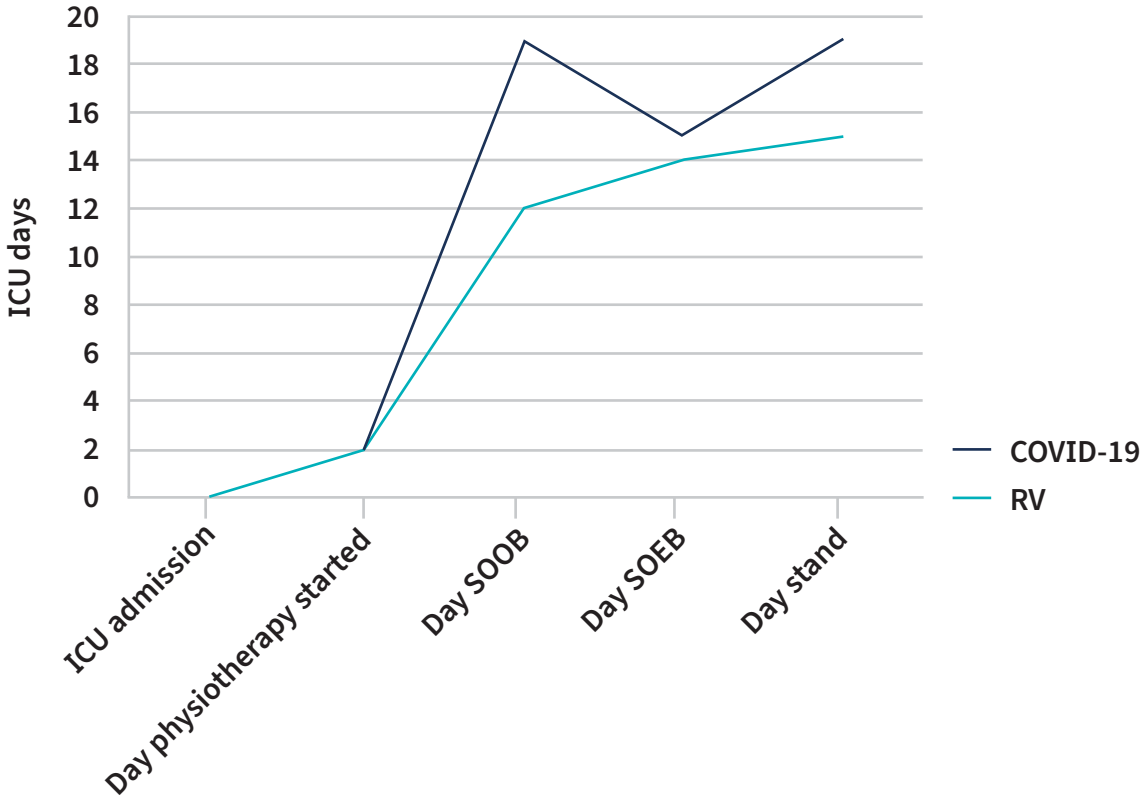


Figure 3: Rehabilitation milestone achievement between mechanically ventilated survivors with COVID-19 and RVs.

Discussion

This is the first evaluation that compares early rehabilitation milestones in ICU between COVID-19 and other RVs. Similar to other studies, male patients were more affected by RVs in the ICU, with a 15–16% increase seen in COVID-19 (2). Unlike gender, we found no significant difference in the ages of patients admitted to ICU with either virus, although our population had a lower average age compared to other studies (2, 10). Hypertension and cardiovascular disease were the most common comorbidities in COVID-19 and RV ICU admissions, however other studies show a higher prevalence of respiratory comorbidities in other viral pneumonias. Our findings are concurrent with comparative studies suggesting that COVID-19 patients experience an additional four to seven days of IMV, as well as a longer length of ICU stay by four to five days (2, 10, 14). Whilst our finding regarding length of ICU stay was statistically insignificant, it may suggest clinical significance with regards to the additional ICU bed costs for COVID-19 patients, as well as the need for more physiotherapy sessions and staff.

There are few studies that analyse rehabilitation trajectories in non-COVID-19 RVs to help us compare our findings. In this study, the achievement of basic rehabilitation outcomes, such as SOOB and standing, was delayed in COVID-19 patients by seven and four days, respectively. Mobilisation began on day 15 by SOEOB in COVID-19 patients. Likewise, other studies show that mechanically ventilated COVID-19 patients begin to mobilise within 15 days of ICU admission (3). The difference between the two groups may be explained by

the greater use of complex ventilation strategies seen in severe COVID-19, such as proned ventilation, NMBAs and extended time of IMV. Previous non-COVID-19 studies associate the development of ICU-AW with risk factors such as IMV for more than five days, NMBAs and proning, however some of these relationships may be considered modest (15, 16). Pre-oxygenation was used twice as much in COVID-19 patients in this study, indicating that physical progression was limited by exertional hypoxia (17).

Furthermore, the significant weeks-worth delay for COVID-19 patients to SOOB may be explained by the limited physical space and mobility equipment during the pandemic. This has also been described in other hospitals, where limiting factors to SOOB included the lack of space, reduced nursing staff availability and altered staffing models (3). However, it is interesting to highlight the delay of rehabilitation milestone achievement within the context of physiotherapy staffing. The 40% increase in ICU physiotherapy team capacity enabled the provision of enough physiotherapy sessions to match a non-pandemic situation – 24 sessions for COVID-19 and 23 for RVs. However, despite these efforts, we continue to see a significant delay in milestone achievement. Therefore, we cannot argue that the delay was due to a lack of physiotherapy staff or number of treatments, thus emphasising the importance of well-staffed teams during high-peak respiratory virus seasons. From a physiological perspective, evidence that compares ICU-AW in COVID-19 to other generic ICU populations discusses the fact that COVID-19 uses angiotensive-converting enzyme two (ACE2) to enter the host cell (18). The expression of ACE2 onto skeletal muscle and nervous cells may lead to additional cytotoxic damage, thus increasing the risk of ICU-AW. However, there are no studies that study ACE2 and ICU-AW between COVID-19 and other RVs to support this statement.

Limitations

The main limitation of this study is the assumption that COVID-19 is a seasonal virus that will add more hospital pressures during the winter months. Epidemiological studies suggest that COVID-19 is temperature-sensitive and, therefore, seasonal, however further studies of full seasonal cycles of the virus are needed to confirm this (19). With regards to the methodology of this study, two outcome measures were not used due to lack of time – the incidence of ICU-AW (through muscle strength testing using the Medical Research Council scale) and the Chelsea Critical Care Physical Assessment Tool (20). Both outcome measures may have helped interpret our results better. Moreover, a survival bias has been acknowledged for this study, where we analysed rehabilitation milestone achievement only in mechanically ventilated survivors. Finally, the lack of patient premorbid status may have supported the interpretation of our findings, however this is a common limitation of ICU research where patients require unplanned and urgent care.

Future research

Future research should include multi-centre studies with larger sample sizes to help with the generalisability of our findings. Follow-up studies that consider rehabilitation outcomes

after discharge from ICU, including home discharge and community follow-up would help describe the long-term outcomes between COVID-19 and other RVs. More recent data for COVID-19 patients should be collected, which will take into consideration the advances that have been made regarding its medical treatment and outcomes. Data should also be collected outside of a pandemic setting to interpret the results under 'normal' working conditions. Furthermore, predictive models for the co-existence of COVID-19 with other respiratory viruses should be linked to this study to help with the development of future ICU rehabilitation staff models.

In conclusion, COVID-19 results in patients requiring longer time-frames to achieve basic rehabilitation milestones when compared to other RVs. The provision of early ICU rehabilitation is key to prevent long-term effects of COVID-19, avoiding successive pressures on hospital and community rehabilitation services. ICU physiotherapy services require advanced planning of resources and staffing during the winter season to account for the added pressure of COVID-19, which is expected to continue occupying ICU bed-spaces despite the development of a vaccine.

Key points

- COVID-19 patients require longer time-frames to achieve basic rehabilitation milestones in the ICU when compared to other RVs.
- Early ICU rehabilitation is key to prevent long-term effects of COVID-19.
- ICU physiotherapy services require advanced planning of staffing and resources, in order to take into account the added pressure of COVID-19 during the winter season.

Funding

No funding was received for this study.

Conflict of interest

There is no conflict of interest associated with this study.

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Rapid adoption of the ICS/FICM guidance for prone positioning in adult critical care within mechanically ventilated patients: a single centre, retrospective evaluation

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Abstract

Introduction

COVID-19 was a global pandemic that resulted in profound respiratory failure. Following promising results from prone positioning reported in Italy and China for patients with COVID-19, it was rapidly instigated in the United Kingdom for treatment for severe respiratory failure. The anticipated high number of admissions, patient prone positioning requirement and staffing challenges associated with the pandemic resulted in a rapid review of local practice.

Methods

This is a single centre, retrospective evaluation of prospectively collected date assessing the safety and feasibility of the rapid adoption of the Intensive Care Society/ Faculty of Intensive Care Medicine guidance for prone positioning of the mechanically ventilated adult. This review included adverse events occuring during prone procedures of all patients with COVID-19 who were mechanically ventilated across two ICUs.

Results

Over 12-months, 123 patients were proned with 1,258 procedures using an adapted checklist. There were three adverse events of iatrogenic nature and one accidental extubation. Less than five prone procedures (0.4%) occurred with between five to eight

members of staff during the two 'proning rounds' rather than with five members of staff as per the guidance. There were no staff injury during the 'proning rounds'.

Conclusion

The rapid adoption of the ICS/FICM guidance was safe and feasible to undertake the prone procedure in clinical practice during the pandemic. This included the prone procedures being performed by five members of staff led by a critical care physiotherapist.

Introduction

The pandemic

COVID-19 became a global healthcare emergency in 2019 as the virus spread profoundly and rapidly. COVID-19 was a global pandemic that led to the death of 6,475,346 people to 2nd September 2022 (1). The virus spread from China, with Italy also being affected early on. The U.K. went into lockdown in March 2020 to try and stem the rapid increase in cases.

Acute respiratory failure is the cardinal clinical presentation of COVID-19 and is associated with considerable mortality (2). Treatments for patients hospitalised for COVID-19 developed rapidly, and relied on anecdotal evidence from other countries, or from more severely affected parts of the U.K. Early reports from Italy (3) and China indicated that mechanically ventilated patients who were prone positioned had associated improvements in their oxygenation and mortality (4).

Prior to the COVID-19 pandemic, prone positioning would be used as a treatment for severe acute respiratory distress syndrome (ARDS) characterised by non-cardiogenic pulmonary oedema and shunted related hypoxemia. Prone positioning improves ventilation and perfusion enabling improvements in oxygenation and is associated with decreased mortality (5). The patient is turned from supine into a prone position for a period of several hours which increases lung volume alongside dorsal lung recruitment, more homogenous ventilation distribution and redistribution of perfusion (6).

Locally, prior to the COVID-19 pandemic, fewer than 10 patients on the intensive care unit (ICU) were prone positioned annually. Usual practice at the time used seven to eight critical care staff members to support in this procedure, which was led by a senior intensivist (7). The anticipated high number of admissions, patient prone positioning requirement and staffing challenges (both numbers and skill mix) associated with the pandemic resulted in a rapid review of local practice.

To deliver the number of prone positioning procedures required in this situation, we changed local practice to five members of staff undertaking this procedure to comply with the recently published ICS/FICM guidelines for prone positioning in adult ICU (8). In March 2020 a local checklist was created along with a brief training programme in preparation for rapid adoption into daily practice.

The clinical effectiveness of prone positioning in COVID-19 and non-COVID-19 related ARDS has been well established (9). However, this change in the process of achieving prone positioning had not been evaluated prior to being instigated, therefore the feasibility and safety was unknown.

Aim

The aim of this single centre evaluation was to assess the safety and feasibility of the rapid adoption of the ICS/FICM guidance in mechanically ventilated patients with COVID-19.

Methods

Ethical consideration

This project was classified as a service evaluation by the NHS trust's research and development office. It was subsequently registered (Ulysses 1705) and followed all local governance processes.

Setting and sample

This service evaluation was conducted in a single centre, U.K. tertiary, university teaching hospital from 1st March 2020 to 28th February 2021. Two ICUs were dedicated as COVID-19 ICUs, increasing the bed numbers from 30 to 52 ICU beds at the peak of the pandemic. Pre-pandemic, critical care physiotherapy was provided from 8am–8pm, seven days per week with staff working a variety of shift durations. During the pandemic this service was extended to provide critical care physiotherapy from 7am–8am with all staff working 13-hour shifts. A senior critical care physiotherapist was present on every shift. The decision to instigate prone positioning was ICU medical consultant/intensivist led.

All prone positioning episodes for all patients with COVID-19 who were mechanically ventilated across both intensive care units (ICU) were included in the service evaluation.

Intervention

The rapid adoption of the ICS/FICM guidelines were implemented through the development of a bedside prone checklist (Figure 1); multi-disciplinary team training through simulation and bedside teaching; and the creation of a YouTube video resource www.youtube.com/watch?v=U_FWLsBoorg (10).

BEFORE THE PROCEDURE

- ☐ Increase FiO_2 100%, charge ETT to soft tie and note length at teeth.
- ☐ Confirm trained/understand procedure.
- ☐ Any contraindications (see below).
- ☐ Emergency equipment located and ready (airway/resus).
- ☐ Eyes taped and lubricated.
- ☐ Stop feed and aspirate NG tube.
- ☐ Disconnect all monitoring except arterial line and capnography.
- ☐ Adequate length on infusion lines?
  - Consider moving pumps.
  - Stop non-essential infusions.
- ☐ Chest drains?
  - Keep below patient, consider clamping.
- ☐ Adequate number of pillows and sheets.
- ☐ Adjust number of pillows and sheets.
- ☐ Adjust height of bed to airway doctor.
- ☐ Allocate roles.
  - ☐ Airway.
  - ☐ Shoulders ×2 A(RHS) and B(LHS).
  - ☐ Hips ×2.
  - ☐ *(Consider 1 if chest drains in situ).*
- ☐ Confirm rolling sequence by teamlead.

RELATIVE CONTRAINDICATIONS

- Unstable shock.
- Tracheostomy <24 hours.

PRONING

- ☐ Equipment.
  - ☐ 4 × pillows, 2 in one pillow case.
  - ☐ 2 sheets.
  - ☐ 1 slide sheet.
- ☐ Confirm adequate sedation.
- ☐ Administer bolus of muscle relaxant.
- ☐ Confirm airway adequately secured.
- ☐ Remove pillow behind head.
- ☐ Insert slide sheet underneath patient.
- ☐ Apply pillows to chest (just under chin) and pelvis (top level with ASIS).
  - Keep abdomen clear.
- ☐ Apply top sheet over patient.
- ☐ Initiate 'Cornish pasty' technique.
  - Ensure sheet tight at shoulders and hips.
- ☐ On instruction of shoulder person A.
  - Slide to patients left side and pause.
  - Rotate 90 degrees and pause.
  - Exchange heads in sequence, one at a time.
  - Shoulders followed by hips.
  - Rotate second 90 degrees.
  - Hip team to reapply monitoring.
  - Shoulder team to position arms.

= Swimmers position with arms and leg fixed on same side.

POST PRONE

- ☐ Confirm ETT length.
- ☐ Unclamp chest drains if needed.
- ☐ Tilt bed head up 30 degrees.
- ☐ Review vent settings.
- ☐ Consider reducing FiO_2
- ☐ Restart NG feed.
- ☐ Confirm abdomen free.
- ☐ Assess pressure areas.
  - ☐ ETT away from face.
  - ☐ Eyes closed/padded.
  - ☐ Ear not bent over.
  - ☐ NG tube pressed against nose.
  - ☐ Penis lying between legs.
  - ☐ Lines not pressing on skin.

POST PRONING BUNDLE

- ☐ ABG >30mins post proning.
- ☐ Alternate limb, leg and head position 4 hourly.
- ☐ Identifying time for re proning :
- ☐ Identifying CPR point with marker = Lower border scapula, down 2 spinous process in midline.

Figure 1: AICU HCID Proning Checklist v 1.3.

The prone checklist recommended the use of five staff members to complete the procedure. This included one airway trained doctor (who was not necessarily ICU based), a critical care physiotherapist and three additional staff members predominantly made up of redeployed staff from theatres, orthopaedics and paediatrics. The critical care physiotherapist led the procedure using the checklist and were available from 7am–8pm daily. At the end of each day the lead critical care physiotherapist ensured that the number of prone procedures undertaken and any adverse events were accurately recorded.

Patients were positioned in prone for 16 hours (5) and aimed to be in the prone position overnight. Therefore, positioning patients into prone and back to supine was undertaken during two 'proning rounds' in the morning and evening. Outside of these hours, procedures were kept to a minimum and led by either an ICU doctor or nurse with the team made up of ICU staff on the night shift.

Data collection

A retrospective review of prospectively collected data recorded in clinical records and the incident reporting system was completed for all included patients.

Each patient reposition was considered to be one procedure (supine to prone, or prone to supine). As the purpose of the evaluation was to assess the safety of the prone procedure and not the effect of prone positioning, an adverse event was defined as an iatrogenic injury occurring during the procedure (for example, endotracheal tube (ETT) or line dislodgement).

Analysis was undertaken using descriptive statistics.

Results

Two hundred and eighty two patients were admitted to the two ICUs with COVID-19 during the evaluation period. Of these, 123 patients were prone positioned while mechanically ventilated on a median of four (IQR 2–6) occasions during this 12-month time period. There were 1,258 procedures of which 27 (2%) occurred out of hours (after 8pm). There were four adverse events recorded (adverse event rate 0.32%) during the prone procedures: two peripheral cannula removals, one nasogastric tube dislodgement and one accidental extubation (Table 1). The accidental extubation occurred out of hours.

Less than five prone procedures (0.4%) occurred with more than five members of staff during the two 'proning rounds'. Of the 27 prone procedures that occurred out-of-hours, the number of times more than five members of staff undertook a procedure is unknown.

Table 1: Patient and prone positioning characteristics.

Characteristic	*n* (%) of patients* *n* = 123
Age med (IQR)	61 (67–54)
BMI med (IQR)	29.7 (25.6–35.3)
<20	2 (2%)
20–30	62 (50%)
>30	59 (48%)
Patients receiving haemofiltration	18 (14%)
Patients with a chest drain	2 (2%)
Prone procedure (per patient) med (IQR)	4 (2–6)
Prone procedure out of proning team hours**	27 (2%)
Adverse events***	4 (0.32%)
NGT dislodgement	1 (0.08%)
Peripheral cannula dislodgement	2 (0.16%)
ETT dislodgement	1 (0.08%)

IQR = interquartile range; BMI = body mass index; NGT = nasogastric tube.

* = Unless stated otherwise.

** = % of total prone procedure *n* = 1,258.

*** = occurred outside the 7am–8pm time frame.

Discussion

This retrospective single centre evaluation demonstrated very low adverse event rates, and the rapid and safe adoption of the ICS/FICM guidelines for prone positioning in adult critical care within mechanically ventilated adults. It is hard to place our very low proportion of adverse rates during the procedure in context as the literature base including a scoping review tends to focus on physiological adverse events related to prone positioning, such as barotrauma or pressure sores (11), as opposed to the process of achieving the position.

The rationale of the allocation of a critical care physiotherapist to the team lead role was to enable the airway trained doctor (who may not have been familiar with the ICU environment) to solely focus on the airway and afforded a consistent leader to support the high proportion of redeployed staff who were less familiar with the environment. It is beyond the scope of this evaluation to assess the contribution of the physiotherapist in this lead role, however this approach developed a pool of expert staff to lead the vast majority of the procedures. Undertaking the procedures during two 'proning rounds' maximised the use of

this expert resource and minimised the number of procedures undertaken overnight when there were additional staffing challenges.

Despite 48% of patients in the evaluation being classified as obese with a BMI over 30 (12), prone positioning could still be safely undertaken with five staff members. Less than five prone procedures occurred with between five to eight members of staff; this was anecdotally due staff confidence due to patients with higher body hiatus during shifts of marked stress levels. Additionally, there were no incidences of staff injury during a prone procedure however, this is only recorded for the two 'proning rounds' whilst it is unknown for the 27 prone procedures out of hours.

Limitations

A limitation during this time period is that the documentation was not as comprehensive as compared to pre-pandemic and therefore some adverse events (for example, peripheral cannula dislodgement) may not have been recorded overnight, however, this is unlikely for more substantial adverse events (for example, ETT dislodgement). This might not be generalisable for other services due to our model that allowed a senior critical care physiotherapist to lead all prone procedures between 7am–8pm. As the purpose of this review was to evaluate the process of positioning a patient into prone, no information was collected on the physiological consequences of prone, or the long-term patient outcomes.

Conclusion

In this service evaluation, it was deemed safe and feasible to undertake prone procedures in mechanically ventilated patients with COVID-19 following the rapid adoption of the ICS/FICM guidance. It was feasible with five members of staff, and led during the two 'proning rounds' by a critical care physiotherapist aiming to provide consistency in the delivery. There was a low rate of adverse rates during the prone procedures, and no recorded staff injury during the two 'proning rounds'.

Acknowledgement

Thank you to all the members of staff within ICU and especially to all the members of staff who were redeployed who supported with the proning procedures. The authors would like to recognise the remarkable teamwork during this period.

Key points

1. Prone positioning with five members was feasible in mechanically ventilated patients following ICS/FICM guidelines.
2. Critical care physiotherapist led prone positioning using a MDT developed checklist resulted in a low rate of adverse events.

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Trach and trace: observational outcomes of patients with COVID-19 who received a tracheostomy during the first pandemic surge in North Central London

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Keywords | COVID-19 pandemic, tracheostomy, weaning, decannulation, length of stay.

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Abstract

Purpose

Insertion of tracheostomy tubes to facilitate ventilator weaning was increasingly indicated during the first COVID-19 pandemic surge and was associated with various recommendations relating to tracheostomy insertion, care and management in this specific cohort. Early publications regarding COVID-19 tracheostomy outcomes were limited by incomplete follow up, small sample sizes and inconsistent variable reporting. Interventions related to weaning a patient from tracheostomy have not previously been reported. We aimed to report a broad set of outcomes in adult patients diagnosed with COVID-19 who required a tracheostomy to contribute to the standardisation of tracheostomy reporting across all populations.

Methods

A multi-centre longitudinal review was undertaken of patients with COVID-19 who required tracheostomies between 4th March and 31st July 2020. Data included; diagnosis, indication for tracheostomy, timing of tracheostomy insertion, tube insertion procedure, size of tube, tube changes, timing of weaning interventions, decannulation, and patient outcomes including length of stay metrics.

Results

Data from 124 patients were included. Weaning from mechanical ventilation was possible from a median of six days (IQR 3–13) and interventions to wean tracheostomy

began on day nine (IQR 4–9). We report a median intensive care LoS of 41 days and median hospital LoS of 53 days. There was a moderate correlation between time to spontaneous breathing trial and the duration of tracheostomy ($r = 0.641$, $p < 0.0001$). Strong correlations were found between tracheostomy duration and duration of ETT ($r = 0.863$, $p < 0.0001$), time to first cuff deflation trial ($r = 0.707$, $p < 0.0001$) and time to first one way valve (OWV) trial ($r = 0.775$, $p < 0.0001$). There were strong correlations between duration of tracheostomy and both intensive care length of stay (LoS) ($r = 0.717$, $p < 0.0001$) and hospital LoS ($r = 0.718$, $p < 0.0001$). Moderate correlations were observed between time from intubation and tracheostomy insertion and both intensive care LoS ($r = 0.519$, $p < 0.0001$) and hospital LoS ($r = 0.378$, $p < 0.0001$).

Conclusion

This report followed patients with COVID-19 who required a tracheostomy during their acute hospital admission, detailing the characteristics of tracheostomy insertion, significant weaning interventions, decannulation, intensive care and hospital discharge. It is hoped that this data contributes to the standardisation of tracheostomy reporting and the ability to evaluate the impact of recommendations for practice modification in the future.

Introduction

The COVID-19 pandemic resulted in large numbers of patients requiring prolonged mechanical ventilation and subsequent insertion of a tracheostomy (1). Initial reports exploring the clinical outcomes of patients with tracheostomy following a COVID-19 diagnosis have been limited by; a lack of standardisation of reported variables, incomplete or short follow up periods, and small sample sizes (2). In particular, the process of tracheostomy weaning in this cohort has not previously been reported.

There is ongoing debate regarding the benefits of tracheostomy placement in terms of reducing intensive care length of stay (LoS) and duration of mechanical ventilation (3, 4, 5, 6, 7, 8). Benefits of tracheostomy include; patient comfort, ease of physical rehabilitation and, the ability to speak, eat and drink (9, 10).

It was recognised that tracheostomy insertion may facilitate an increase in intensive care bed capacity during the first U.K. COVID-19 surge (11, 12). COVID-19 is highly contagious and tracheostomy insertion is thought to be an aerosol generating procedure (AGP) therefore, the procedure poses risk to healthcare professionals (13). In order to mitigate risk, international guidance was produced for tracheostomy insertion (14, 15, 16) in patients with COVID-19. Delaying tracheostomy insertion may reduce risks for healthcare workers (13), however a delay in tracheostomy insertion has the potential to expose the patient to

the known risks of prolonged intubation (17, 18). The relationship between time to tracheostomy insertion and clinical outcomes in patients with COVID-19 remains unclear.

Aims

The aim of this project was to report observational outcomes in adult patients diagnosed with COVID-19 who required temporary tracheostomies over the time period covering the first pandemic wave (6th March 2020–31st July 2020) The specific objectives were to report:

- Time from intensive care admission to tracheostomy; extubation trial prior to tracheostomy and time from intubation to tracheostomy. Time from intubation to tracheostomy may be explored for temporal categorisation depending on the data distribution.
- Ventilator and tracheostomy weaning interventions including; time to first cuff deflation, time to first one way valve (OWV) application, OWV use 'inline' with the ventilator, and time to spontaneous breathing trials (SBT).
- Decannulation outcomes including; time to decannulation, successful decannulation and the clinician responsible for decannulation.
- Intensive care and hospital LoS.
- Associations between patient/tracheostomy characteristics and patient outcomes.

Methods

Patient sample

Adult patients (aged >16 years) diagnosed with COVID-19 who required a tracheostomy inserted between 6th March–31st July 2020 at four acute hospital sites in London (St Bartholomew's Hospital, The Royal London Hospital, The Royal Free Hospital, and Homerton University Hospital). Patients with long-term tracheostomies originally prior to admission were excluded.

Data collection

Prior to (and during) the COVID-19 pandemic each service routinely collected data on patients with a tracheostomy through a common 'minimal data set' (Box 1). Data collection continued up to 1st October 2020. Cohort data from each site was subsequently anonymised and combined to create a single database. Prior to analysis, the database was scrutinised for consistency and coding and corrections made as required.

Box 1: Minimum data set.

- Demographic information.
- Diagnosis.
- Indication for tracheostomy.
- Tube insertion date and procedure.
- Size of tube inserted.
- Tube changes.
- Decannulation dates and outcomes.
- Dates of discharge from intensive care, and the acute hospital.
- Date of death for non-survivors.
- Successful decannulation was defined as the patient not requiring reinsertion of the tracheostomy tube within the 48 hours following decannulation.
- Failure was defined as requiring tube reinsertion within 48 hours, and the failure reason was recorded (19).
- Weaning milestones:
  - First cuff deflation.
  - First one-way valve application.

Data analysis

Statistical analyses were performed using Microsoft Excel and IBM SPSS Statistics. Data normality was assessed by data distribution in histograms and differences between means and medians. Descriptive statistics of numerical variables are presented as means and standard deviation (SD) if normally distributed and otherwise as medians and interquartile ranges (IQRs). Categorical variables are presented as numbers and percentages. Numeric and binary categorical variables were compared using the independent sample *t*-test for parametric data and Mann Whitney U tests for nonparametric data. For comparisons between a numeric variable and a categorical variable with more than two groups, Kruskal Wallis ANOVA was utilised. For comparing categorical variables, Chi square and Fishers Exact test were used for parametric and nonparametric data respectively. A time to event analysis was completed for intensive care and hospital LoS. Initial analysis of the 'time from intubation to tracheostomy' variable (for example, duration of endotracheal tube) delineated three distinct groups [<15 days (early), 15–27 days (late) and >27 days (delayed)], which were subsequently used to assess between group differences.

Approval

Ethical approval was not sought as the project was deemed a service evaluation by the Clinical Effectiveness Unit (CEU) at all sites.

Results

Tracheostomy data from 124 patients were included in the analysis (Figure 1).

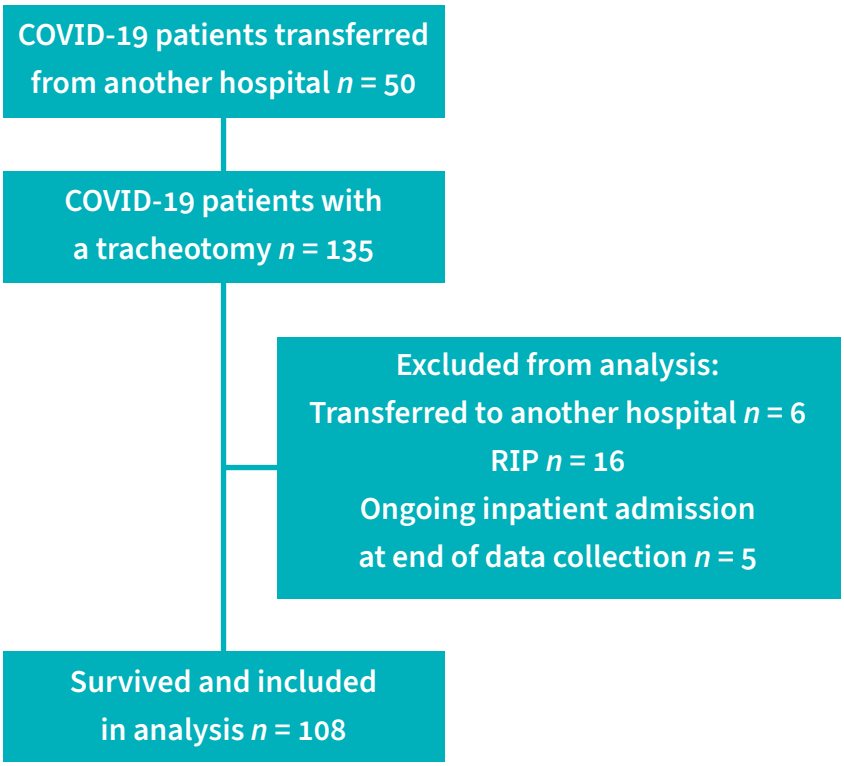

Figure 1: Tracheostomy data included in analysis.

Demographics

Demographics and baseline characteristics of the sample are displayed in Table 1.

Table 1: Demographics and baseline characteristics.

	All patients *n* = 124	Group 1 early tracheostomy (<15 days) *n* = 36	Group 2 late tracheostomy (15–27 days) *n* = 55	Group 3 delayed tracheostomy (>27 days) *n* = 33	*p* value
Age	58.3 ± 10	58.60 ± 9.84	59.37 ± 9.64	56.31 ± 12.00	0.493
% Male (*n*)	78.2% (97)	75% (27)	72.7% (40)	90.9% (30)	0.116
Admission source*					
Ward	59 (48%)	24 (66.7%)	28 (50.9%)	7 (21.2%)	
Emergency Department	49 (40%)	9 (25%)	22 (40%)	18 (54.5%)	0.003
Other hospital	16 (13%)	3 (8.3%)	5 (9.1%)	8 (24.2%)	
Time from intensive care admission to intubation	0.00 (0–0)	0 (0–1)	0 (0–0)	0 (0–0)	0.516
Time from intubation to tracheostomy	20 (15–27)				
Reason for tracheostomy					
• Primary Airway.	8 (6%)	3 (8.3%)	4 (7.3%)	1 (3%)	
• Low arousal state.	13 (10.5%)	3 (8.3%)	8 (14.5%)	2 (6.1%)	
• Facilitate weaning.	101 (81.5%)	28 (77.8%)	43 (78.2%)	30 (90.9%)	0.247
• Agitation/delirium.	2 (1.6%)	2 (5.6%)	0	0	
Insertion procedure					
• Percutaneous.	47 (37.9%)	10 (30.3%)	22 (40%)	15 (45.5%)	0.291
• Surgical.	77 (62.1%)	26 (78.7%)	33 (60%)	18 (54.5%)	
Trial of extubation prior to tracheostomy					
• Yes.	19 (15%)	7 (19.4%)	7 (12.7%)	5 (15.1%)	
• No.	105 (85%)	29 (80.6%)	48 (97.3%)	28 (84.9%)	0.685
Size of tube at insertion					
• Size 6.	0 (0%)	0	0	0	
• Size 7.	39 (32%)	14 (38.9%)	16 (29.1%)	9 (27.2%)	0.173
• Size 8.	74 (60%)	16 (44.4%)	36 (65.5%)	22 (66.7%)	
• Size 9.	11 (8%)	6 (16.7%)	3 (5.5%)	2 (6.1%)	

Results are presented as median (IQR) and *n* (%).

* = ward: transferred from within the same hospital from ward based care to intensive care. Emergency department: transferred from emergency department to intensive care. Other hospital: transferred to intensive care from another hospital both within and outside of the University college London Partners (UCLP) network.

Ventilator and tracheostomy weaning interventions

Interventions that facilitate mechanical ventilation and tracheostomy weaning, including cuff deflation, OWV application, and spontaneous breathing trials (SBT) are displayed in Table 2.

Table 2: Outcomes related to interventions to facilitate ventilator and tracheostomy weaning.

	All patients	Group 1 early tracheostomy (<15 days) *n* = 36	Group 2 late tracheostomy (15–27 days) *n* = 55	Group 3 delayed tracheostomy (>27 days) *n* = 33	*p* value
Time to first cuff deflation trial (days)	*n* = 109 9 (4–9)	*n* = 30 10 (4.75–17.25)	*n* = 49 9 (4–16)	*n* = 30 8 (4–15)	0.874
Time to first one way valve (days)	*n* = 108 10 (15–17)	*n* = 29 10 (5–17.5)	*n* = 49 10 (4–17.5)	*n* = 30 9 (9–18.25)	0.948
Inline one way valve trialled		*n* = 36	*n* = 55	*n* = 33	
• Yes.	12 (9.7%)	5 (13.9%)	5 (9.9%)	2 (6.1%)	0.536
• No.	112 (90.3%)	31 (86.1%)	50 (90.1%)	31 (93.9%)	
Time from tracheostomy insertion to first spontaneous breathing trial (days)	*n* = 109 6 (3–13)	*n* = 30 8 (2.75–15.5)	*n* = 49 5 (3–12.5)	*n* = 30 5.5 (3–13.25)	0.668

Values are reported as median (IQR) and *n* (%).

Tracheostomy management and outcome

The incidence of complications associated with tracheostomy, tracheostomy duration and patient outcomes including intensive care and hospital LoS are displayed in Table 3, Figure 2 and Figure 3.

Table 3: Tracheostomy management and outcome.

	All patients	Group 1 early tracheostomy (<15 days) *n* = 36	Group 2 late tracheostomy (15–27 days) *n* = 55	Group 3 delayed tracheostomy (>27 days) *n* = 33	*p* value
Required emergency tube changes during course of insertion		*n* = 36	*n* = 55	*n* = 33	
• Yes.	12 (10%)	4 (11.1%)	7 (12.7%)	1 (3%)	
• No.	112 (90%)	32 (89.9%)	48 (97.3%)	32 (97%)	0.109
Required routine tracheostomy tube changes during course of tracheostomy insertion		*n* = 36	*n* = 55	*n* = 32	0.654
• Yes.	14 (11%)	3 (8.3%)	6 (10.9%)	2 (6%)	
• No.	109 (89%)	33 (93.7%)	47 (89.1%)	29 (94%)	
Time to tracheostomy decannulation from insertion (days)	*n* = 106 21.0 (13–32)	*n* = 28 9 (14–27.75)	*n* = 49 21 (12.5–35)	*n* = 29 21 (11–32.5)	0.791
Time to decannulation from initial intubation (days)	*n* = 106 42 (31–53)	*n* = 28 31 (25–42)	*n* = 49 43 (33.5–53)	*n* = 29 51 (40.5–64.5)	>0.0001
Clinician responsible for tracheostomy decannulation	*n* = 106	*n* = 28	*n* = 49	*n* = 29	
• Medical staff.	29 (31%)	8 (28.6%)	12 (24.5%)	9 (31%)	
• Physiotherapist.	67 (63%)	18 (64.3%)	31 (63.3%)	18 (62%)	0.358
• Other AHP.	0	0	0	0	
• Nursing.	6 (4.7%)	2 ((7.1%)	2 (4.1%)	2 (7%)	
• Self-decannulated.	4 (3.8%)	0	4 (8.2%)	0	
Tracheostomy decannulation successful at 48 hours	*n* = 106	*n* = 28	*n* = 49	*n* = 29	
• Yes.	104 (98%)	26 (92.3%)	49 (100%)	29 (100%)	0.224
• No.	2 (1.8%)	2 (99.7%)	0	0	
Patient outcomes					
• RIP tube in situ.	17 (13.7%)	7 (19.4%)	6 (10.9%)	4 (12.1%)	
• Transfer tube in situ to another hospital.	8 (6.5%)	3 (8.3%)	3 (5.5%)	2 (6%)	
• Transfer tube in situ to rehabilitation unit.	2 (1.6%)	1 (2.8%)	1 (1.8%)	0	0.718
• RIP post decannulation.	1 (0.8%)	0	1 (1.8%)	0	
• Discharged from hospital post decannulation.	91 (74.4%)	22 (61.1%)	43 (78.2%)	26 (78.8%)	
Total hospital length of stay. Median days (IQR)	53 (38–74)	36 (27.25–52)	56 (41–78)	63 (52–86.5)	*p* >0.0001
Intensive care length of stay. Median days (IQR)	41(32–49)	32 (22–37.5)	42 (32–48)	49 (41–69.5)	*p* >0.0001

Values are reported as median (IQR) and *n* (%).

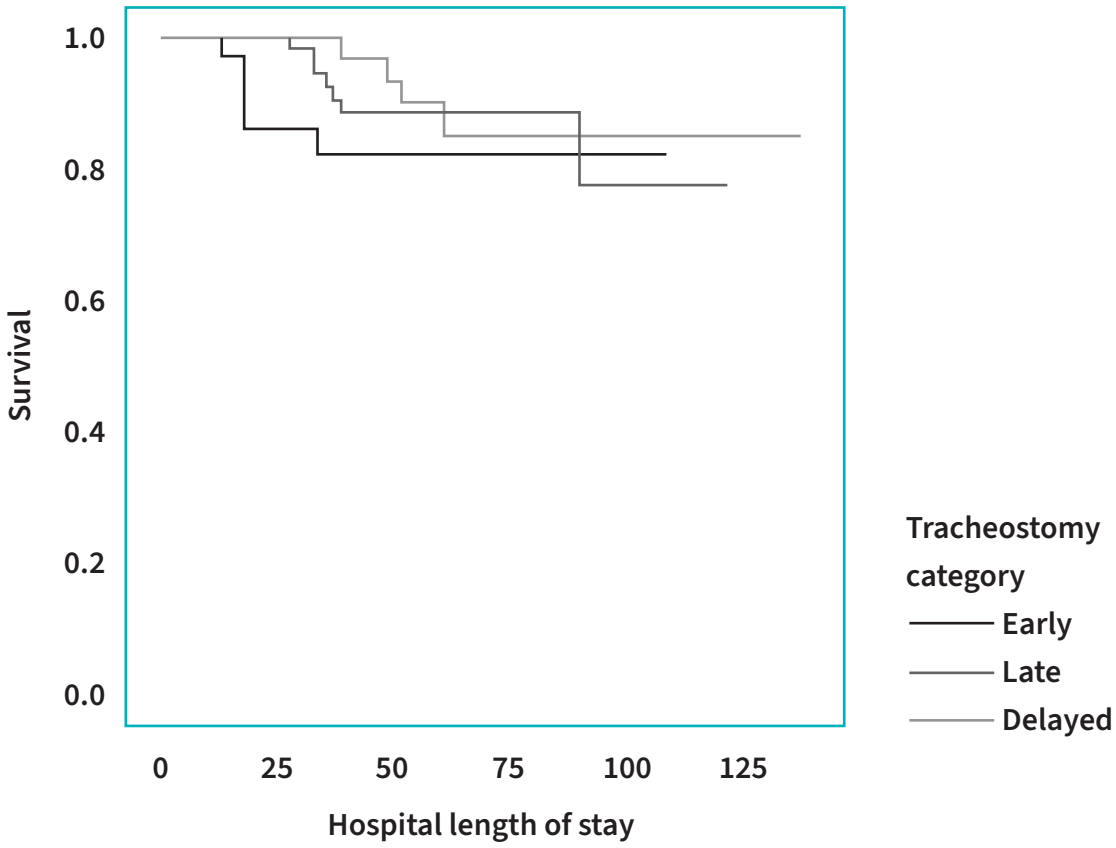

Figure 2: hospital length of stay time to event curve.

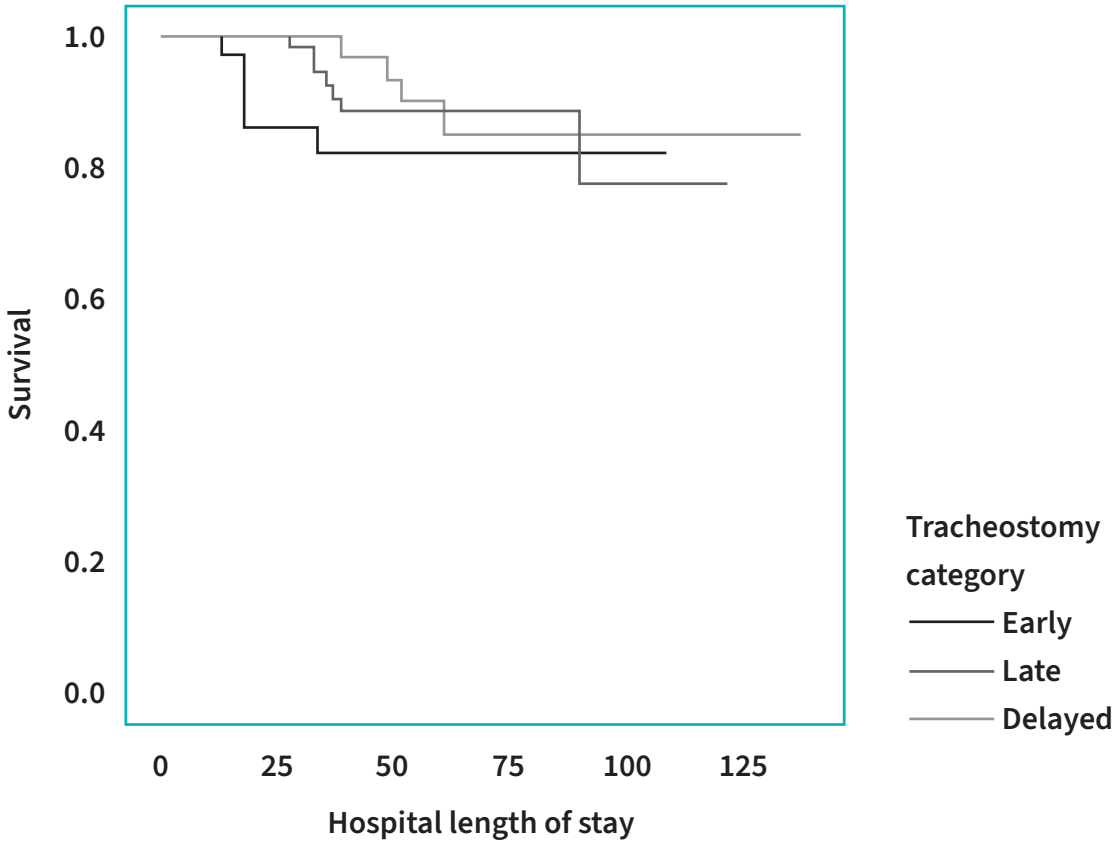

Figure 3: Proportion of patients remaining in hospital.

Associations between patient/tracheostomy characteristics and patient outcomes

Relationships between the time from intubation to tracheostomy (for example, duration of ETT or time to tracheostomy) and variables which might impact this were explored. There was no correlation between time to tracheostomy and age (r = -0.095, p = 0.292), length of intensive care stay prior to intubation (r = -0.173, p = 0.064), or reasons for tracheostomy insertion (p = 0.229). There was no difference in time to tracheostomy between those who trialled 'inline' OWV and those who did not (p = 0.501). No correlations were found between time to tracheostomy and time to SBT (r = 0.060, p = 0.538), time to first cuff deflation trial (r = 0.008, p = 0.0934) or time to first OWV trial (r = 0.035, p = .719). There was a difference in time to tracheostomy between those patients who were transferred between hospitals (26 days (19, 31) and those who were not (17 days (11, 24) (p <0.0001). Moderate correlations were observed between time to tracheostomy and both intensive care LoS (r = 0.519, p <0.0001) and hospital LoS (r = 0.378, p <0.0001).

The extent of any relationship between the time to decannulation from tracheostomy insertion (tracheostomy duration) and variables which might impact this were explored. There was no correlation between duration of tracheostomy and age (r = 0.079, p = 0.422), time to intubation from intensive care admission (r = 0.33, p = 0.746), or reasons for tracheostomy insertion (p = 0.531). There was no difference in tracheostomy duration between those who trialled an 'inline' OWV and those who did not (p = 0.876). There was a moderate correlation between time to SBT and the duration of tracheostomy (r = 0.641, p <0.0001). Strong correlations were found between tracheostomy duration and duration of ETT (r = 0.863, p <0.0001), time to first cuff deflation trial (r = 0.707, p <0.0001) and time to first OWV trial (r = 0.775, p <0.0001).

Discussion

Baseline characteristics and time from intubation to tracheostomy

The characteristics of our cohort are consistent with previous COVID-19 tracheostomy reports (16, 20, 21, 22, 23). The predominant indication for tracheostomy insertion was to facilitate ventilator weaning (81.5%). Extubation trials prior to tracheostomy insertion occurred in only 15% of our sample which is in keeping with other practice guidelines (11).

A COVID-19 report from the U.K. (20) demonstrated no difference in survival between patients receiving tracheostomy before 10 days or after 10 days (p = 0.73) although only nine patients underwent tracheostomy before day 10 making statistical interpretation difficult. Similarly, no difference in survival was reported in those who underwent a tracheostomy before or after day 14 (p = 0.18). These authors also report shorter duration of mechanical ventilation and reduced intensive care LoS in patients where tracheostomy was performed before day 14 compared to after day 14 (20). Data from COVIDTrach (24) reported median time to tracheostomy in the U.K. was 15 days and mortality 18%. A further U.K. study reported a tracheostomy before day 14 was associated with a reduced LoS (25). The PRoVENT

study (26) reported a median time to tracheostomy of 21 days, with a tracheostomy being performed before 21 days being associated with shorter duration of mechanical ventilation but higher mortality. Additionally a meta-analysis indicated early tracheostomy was associated with reduced duration of mechanical ventilation and intensive care stay (1). The longer time to decannulation, intensive care and hospital LoS observed in our delayed tracheostomy group appears to be in keeping with other literature (22, 23). Our report was not designed to evaluate the impact of timing of tracheostomy insertion and the observational nature of our report means we cannot suggest causation. It appears that the decision to insert a tracheostomy should be a multi-professional decision where patient acuity and on-going intervention plans are considered.

Interventions to facilitate ventilator and tracheostomy weaning

We report weaning interventions in COVID-19 patients with tracheostomy. It is accepted that mechanical ventilation is a barrier to communication, resulting in patients' feelings of anxiety and helplessness (27, 28). Provided a patient can tolerate cuff deflation, a OWV can be inserted 'inline' with ventilator tubing to restore voice and enable oral intake. OWV utilisation was not recommended for patients with COVID-19 (29). In our cohort, 9.7% of patients underwent 'inline' OWV. We advocated 'inline' OWV to facilitate communication (especially in the presence of delirium), on a case-by-case basis. 'Inline' OWV did not impact tracheostomy duration ($p = 0.876$) nor benefit ventilator or tracheostomy weaning and risk versus benefit should be continuously evaluated. It is difficult to establish the prevalence of this technique in clinical practice but this may be an meaningful outcome for patients.

Decannulation outcomes

We report a mean time to tracheostomy decannulation of 21 days. An Italian sample of patients with COVID-19 (30) reported mean time to decannulation of 36 days, while a U.K. cohort reported 12.7 days (20) and an American study reported 16.6 days (16). It should be noted patients in these previous reports had not completed their intensive care or hospital admission, making comparison difficult. Our report has a longer duration of follow up compared to previous COVID-19 literature and may more accurately reflect the duration of tracheostomy in a COVID-19 cohort. International and institutional differences in practice may account for the variation in tracheostomy duration observed.

The clinician responsible for tracheostomy decannulation in our cohort was the physiotherapist in 63% of cases and decannulation was successful in 98% of cases. Our data suggest physiotherapists at our centres have the ability to successfully manage tracheostomy decannulation, which may release medical staff to complete tasks specific to their own practice. The clinician performing decannulation procedures in other COVID-19 literature remains unreported.

Hospital outcomes including mortality, intensive care and hospital length of stay

The mortality rates for tracheostomy patients with a COVID-19 diagnosis vary in the literature. Mortality at a London tertiary centre were reported as 9.7% (31), although follow-up

data were only available for 14 days post tracheostomy. Botti et al (30) reported a mortality rate of 34.1%, although it is unclear how long the follow up period was. Data from another U.K. cohort reported 30 day mortality rate for patients with tracheostomy of 31.7% (20) and Chao et al (16) reported a rate of 11.3%, although their dataset was incomplete. Martin-Villares et al (23) reported a 23.7% mortality at one month follow up in a COVID-19 tracheostomy cohort. The mortality rate observed in our study was low (12.9%), and whilst we are unable to identify causes for this, it may reflect the longer follow up period we report. We acknowledge that mortality may have been impacted by institutional and international differences in the management of COVID-19 as understanding about management of the virus improved over time.

We have reported a difference in duration of ETT for patients who were transferred between hospitals and those who were not. Inter-hospital transfers occurred to alleviate intensive care capacity and facilitate specialist management such as renal filtration, extracorporeal membrane oxygenation (ECMO) and insertion of tracheostomy. Our data suggest that in our geographical location, transferring patients between hospitals may be related to increased time to tracheostomy insertion and ventilator weaning. We suggest intensive care networks consider this finding in their planning for surge capacity and minimise transfer of patients between intensive care units.

There is a paucity of literature regarding intensive care LoS for patients with COVID-19 who received a temporary tracheostomy. International studies have reported average intensive care LoS of 11 (31), 22 (30) and 25.3 days (20) for patients with COVID-19 and tracheostomy. Hospital LoS for patients with COVID-19 who required a tracheostomy is even rarer with only one reported hospital LoS of 37.2 days (20). The short follow up period for these studies means many participants still had their tracheostomies in situ when the data was reported. We report a median intensive care LoS of 41 days and median hospital LoS of 53 days. Since our data is derived from a larger cohort following patients until they are discharged from the acute hospital, the longer intensive care and hospital stay we report may be a more accurate reflection of these metrics for our geographical location.

Relationships between patient/tracheostomy-characteristics and the duration of ETT

It might be expected that primary airway difficulty as the indication for tracheostomy was associated with longer duration of tracheostomy. This concept was not supported by our data, as there was no difference in duration of tracheostomy between the reasons for tracheostomy insertion ($p = 0.247$), however it may be difficult to draw conclusions on whether reason for tracheostomy impacted duration of tracheostomy as numbers for other indications were small (Table 1). We could find no other examples in the tracheostomy literature with which to compare or contrast these relationships.

Relationships between patient/tracheostomy characteristics and time to decannulation

We report moderate and strong correlations between tracheostomy duration and time to

first cuff deflation trial, time to first OWV trial and time to SBT. Additionally, there were strong correlations between time to tracheostomy and both intensive care LoS and hospital LoS. The MDT approach to tracheostomy weaning within our centres promotes the adoption of early weaning interventions (32). Whilst correlation does not indicate causation, these data support the role of weaning interventions in facilitating tracheostomy weaning and reducing associated LoS. In a non-COVID-19 cohort, time to tracheostomy decannulation was reported as 18 to 13 days, with time to cuff deflation 9 to 7 days (33). A further non COVID-19 study demonstrated time to first cuff deflation as 17 to 10 days and time to OWV use as 14 to 7 days (34). There is a paucity of reporting of weaning interventions making comparisons between our results and both COVID-19 and non-COVID-19 cohorts difficult.

Limitations

Our report is observational in nature for which we must recognise inherent bias. The observational design means inferences and generalisability of results are not possible, and we have not accounted for confounding factors. We did not record duration of mechanical ventilation (which other reports were able to state). We did not record co-morbidity, ethnicity, body mass index or severity of illness to determine whether these inherent risks influenced the results. Neither did we record other inventions patients may have received as part of management of their condition, such as prone positioning which could further confound our results. Regression analysis may have mitigated some of the confounding factors and this approach could be utilised in future work.

Conclusion

This report followed patients admitted to four London hospitals with COVID-19, who required a temporary tracheostomy, until decannulation and hospital discharge. The majority of COVID-19 survivors from these London hospitals who received a tracheostomy were successfully weaned and decannulated with multi-disciplinary team interventions. Comparison between this report and other COVID-19 and non-COVID-19 tracheostomy outcomes is limited due to differences in sample sizes, follow up periods and reporting standards. Inter-institutional and international comparisons of clinical outcomes following tracheostomy insertion may be improved by the development of core variables for tracheostomy reporting. Implementing core variables for tracheostomy reporting may allow the effect of changes to care and management (as occurred during the COVID-19 pandemic) to be robustly evaluated.

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Declaration of interests

No competing interests to declare.

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Is an online exercise platform, such as Pactster/Beam an acceptable tool to promote exercise participation in adults with cystic fibrosis, with or without online physiotherapy support?

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Keywords | CF, online exercise, FEV_1, physiotherapy.

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Abstract

Background

Cross infection risk prevents CF patients from exercising together. We assessed if www.pactster.com, an online CF specific support platform is an acceptable and clinically effective method to promote exercise participation amongst adult CF patients and assessed its use with online physiotherapy support. Since the time of study the website has rebranded as www.beamfeelgood.com. For the purpose of this paper, it will be referred to as Pactster as its original form.

Methods

In a randomised controlled trial, 30 patients who identified as exercising <150 minutes/week were randomised to one of two closed online communities within the Pactster website: Pactster alone, which comprised of recorded online exercise videos and peer support versus Pactster and physiotherapy input, which included supported, scheduled exercise sessions and daily motivation from their specialist centre physiotherapist. The primary outcome was acceptability, measured at study completion at six weeks with a yes/no question. Other measures included lung function, exercise tolerance (Chester step test) and generic health status (EQ-5D-5L).

Results

Of 230 patients, only 75 (33%) reported >150 minutes of exercise/week. 30 patients who identified as completing <150 minutes of exercise/week participated in the RCT, and 25 reported that Pactster was acceptable (p <0.001). For % predicted FEV_1, there was a 6% difference between groups favouring the physiotherapy group.

There was an improvement of 1.5 minutes in the Chester step test seen in the physiotherapy group, with no change in the Pactster alone group. The adjusted and unadjusted differences in utility and quality adjusted life years were similar in both arms.

Conclusions

This small study has shown that patients find the online exercise platform an acceptable approach to promote exercise participation in those that are motivated to access exercise support. Physiotherapy support was well received and may improve clinical outcome, though these results must be interpreted with caution given the small trial size, and require replication in a larger study.

Highlights

- Patients with CF cannot exercise together due to the risk of cross infection.
- Online exercise platforms allow group exercise and virtual interaction.
- In this study, an online exercise platform is acceptable to 83% of patients.
- Additional online physiotherapy support may improve FEV_1.

Background

Exercise is strongly promoted as part of a comprehensive treatment plan for people with cystic fibrosis (CF). As well as pharmacological treatments, CF management requires intensive physiotherapy input in terms of chest clearance and the promotion of activity. Regular exercise is positively associated with measures of fitness and lung function in those with CF (1, 2) and is strongly promoted by the U.K. Cystic Fibrosis Trust (3). Furthermore, peak aerobic capacity has been shown to be associated with better lung function and lower mortality rates (4). Adults should perform 150 minutes or more of moderate aerobic activity per week (5, 6). Disease severity may require the amount of exercise to be adjusted, although patients who are more physically restricted are still encouraged to engage in activity.

Evidence for the apparent benefit of exercise mostly comes from observational studies or before-and-after intervention studies, with few randomised controlled trials (RCT) to prove causality (7). One year-long RCT showed that an unsupervised exercise training programme improved fitness assessed by changes in blood lactate levels (8), whilst a three year-long program for CF patients aged 7–19 failed to show an improvement in exercise tolerance; this latter trial did not meet its primary endpoint which was decline in forced expiratory volume in one second (FEV_1) (-3.47 versus -1.46, $p = 0.07$), but did show a difference in decline in forced vital capacity (FVC) (-2.42 versus -0.25, $p = 0.02$) favouring the exercise programme (9). A six-month partially-supervised training programme included three groups: strength training, endurance training and controls (10). Both interventions showed a clinical and statistical improvement in FEV_1, with an improvement in aerobic performance, though benefits were not sustained. The authors attribute this in part to the lack of ongoing supervision.

Adherence with exercise is poor (11) with low self-reported adherence rates (24%) despite patients' recognition of the benefits of exercise (12).

Patients with chronic obstructive pulmonary disease (COPD) report that group pulmonary rehabilitation helps individuals come to terms with their chronic illness and overcome the initial barriers to physical activity; furthermore they value support from a supervising healthcare professional (13). Group based exercise programmes are restricted in CF due to the risk of cross-infection. Online exercise classes can potentially overcome this barrier, whilst providing the community support seen in traditional pulmonary rehabilitation. Furthermore, they permit virtual support from a trained CF physiotherapist to tailor exercise programmes and provide encouragement.

Pactster (now rebranded as BEAM Cystic Fibrosis, www.beamfeelgood.com) is a health specific online exercise video resource which was initially launched in May 2016 and was free for people with CF, with funding provided by the U.K. Cystic Fibrosis Trust. This permitted patients with CF to exercise virtually as a group, with physiotherapy support via an online interactive forum. In this study, we assess the feasibility of Pactster as a tool to promote exercise participation, and in a randomised controlled trial (RCT) we compared access to Pactster alone to Pactster plus online physiotherapy support. This research was conducted prior to the COVID-19 pandemic. The concept of online exercise has now got a much larger reach out of global health necessity, and therefore it remains important to understand its place in healthcare moving forward. Since conducting this research Pactster has since rebranded as BEAM Cystic Fibrosis but uses the same concept and support network. For the purposes of this research, it will be continued to be referred to as Pactster.

It is important to recognise the recent role cystic fibrosis transmembrane conductance regulator (CFTR) modulator treatments have had in CF care. The face of CF is evolving and there is an increasing focus on exercise as modulators have the potential to improve exercise capacity. It is important that clinicians can meet this changing need and provide suitable options to allow structured exercise support away from the CF centre for sustainable care. Although this study commenced prior to the licensing of what are now common treatments (Kaftrio), their role in the future of CF care needs to be considered.

Method

Thirty patients were randomised to receive:

a Pactster plus online physiotherapy support.
b Pactster alone.

We used a physical activity questionnaire to measure patient reported exercise and barriers to exercise participation in all adult CF patients attending clinic between April–July 2018.

Eligibility criteria was: a percent predicted FEV_1 ($ppFEV_1$) of 30% or more, internet access, and patient reported exercise totalling less than 150 minutes a week. Exclusion criteria included lung transplantation, significant arthropathy or osteoporosis, neurological disease, supplementary oxygen, and immobility.

The intervention was online physiotherapy support via the Pactster website. The physiotherapists posted daily encouraging messages within the private community and provided the opportunity for users to engage in discussion and plan supervised workouts. The physiotherapist scheduled two exercise sessions per day (10am and 3pm) of varying content, which were later increased to include one evening session (6.30pm) and a Saturday morning session (9am) at the users request.

In the control group, (Pactster Alone) users were aware they were to be self motivated and utilise the available resources. Patients in both arms of the study had access to the same Pactster exercise video library content, they could communicate with each other via their retrospective closed community to provide peer encouragement, and received face-to-face physiotherapy input as per usual CF care, for example routine clinic visits. The control group received no scheduled sessions or additional online physiotherapist support.

The primary outcome was the acceptability of Pactster to all patients included in the RCT at six weeks. We compared changes from baseline and six weeks' follow up with regards to exercise capacity (measured by the Chester Step Test), $ppFEV_1$ and EQ-5D-5L between groups. By meeting the inclusion criteria, all participants were deemed to be clinical stable at the start of the trial. The Chester Step Test is a multi-staged exercise test, in which patients repeatedly step up and down onto a 20cm high box at a progressively increasing pace. The aerobic capacity is predicted by plotting repeated measures of heart rate through which a line of best fit is plotted, projecting up to the maximum heart rate and an estimate of corresponding oxygen uptake (14). As per the Chester Step Test Protocol 8" (20cm) Step is generally suitable for those under 40 years of age who take little or no regular physical exercise.

Physiotherapy time was recorded to calculate the additional costs incurred by online physiotherapy support.

Ethics approval was provided by the North West Greater Manchester East Research Ethics Committee (18/NW/0247).

Statistical methods

The primary outcome was the acceptability of Pactster to all patients involved in the study, in a binary 'yes/no' question. A sample size of 22 was required in a single-sample binomial analysis to have 80% power to the 0.05 significance level, assuming an 80% acceptability rate. The null hypothesis was that half of patients would report that Pactster

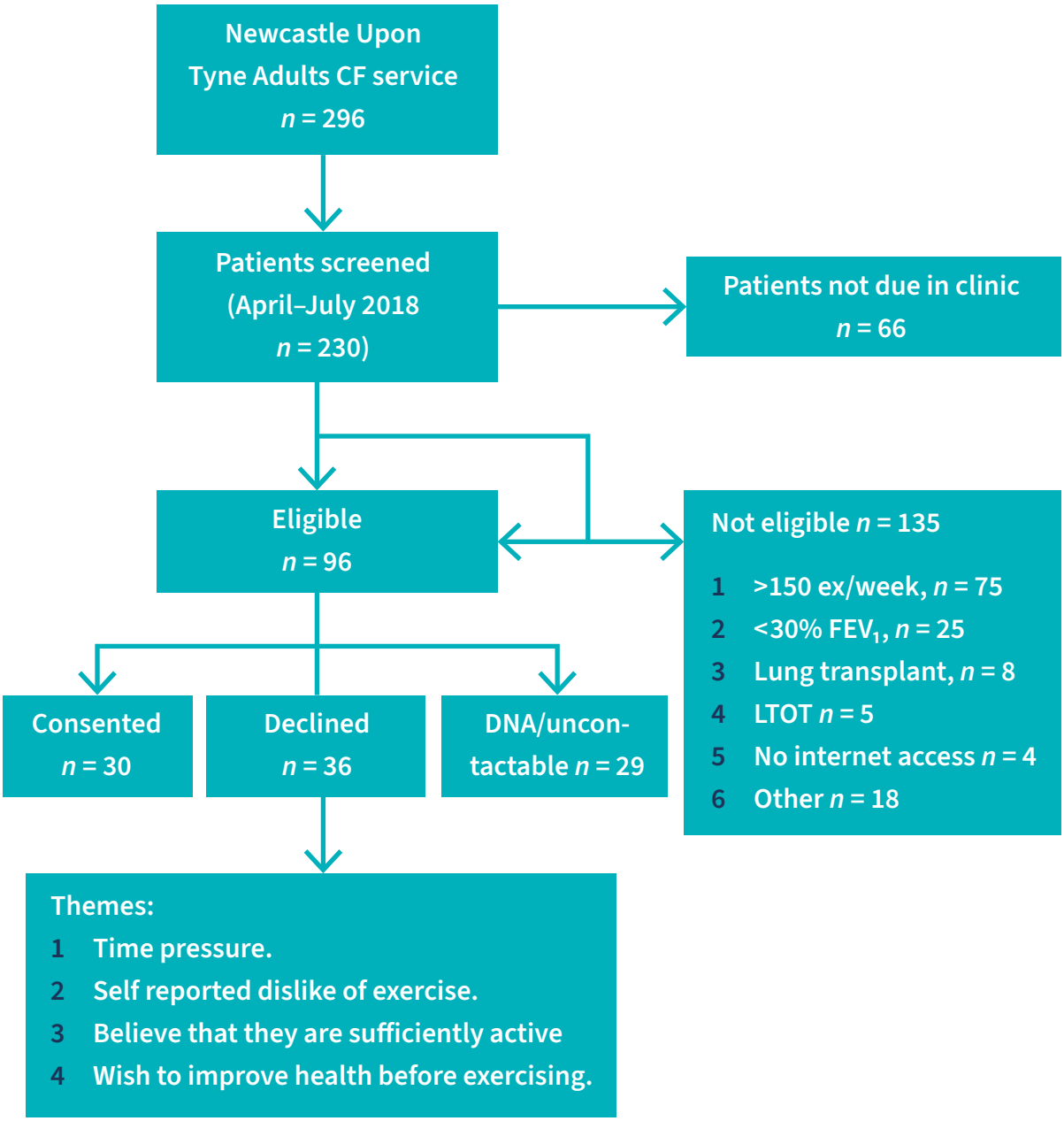
was acceptable. We assumed Pactster was unacceptable in non-responders. Patients were randomised using www.sealedenvelopes.com.

Means and 95% confidence intervals (95% CI) were provided for data that is normally distributed, otherwise medians and interquartile ranges (IQR) were used. The total hours of support provided by the physiotherapist was calculated. Data used to estimate quality adjusted life-years (QALY) was collected using the EQ-5D-5L. This collects information regarding patient's health-related quality of life, which was transformed using a standard algorithm to produce a health status utility score. Mean QALY differences between the groups was generated from patient's utility values using a regression approach, controlling for baseline utility, intervention group, ppFEV$_1$, sex and age.

Results

A total of 230 (78%) patients were screened out of the 296 patients under the care of the Adult Newcastle upon Tyne Service (Figure 1) between April 2018–July 2018. The remaining 66 patients who did not attend clinic in this time were mostly those with minimal lung disease. Of the 230 patients, only 75 (33%) reported doing more than 150 minutes of exercise a week, with two-thirds performing insufficient or no exercise.

Figure 1 shows information from the physical activity questionnaire and screening, with barriers to exercise in those that did not want to participate in the RCT and declined to do more exercise. The reasons for declining to do more exercise included: time pressures and restrictions, an active dislike of exercise despite encouragement, or the perception that online exercise was 'not their thing'.



DNA = did not attend, LTOT = long term oxygen therapy.

Figure 1: Overview of CF patients and exercise participation, and eligibility for the randomised controlled trial.

Thirty of 95 eligible patients consented to take part in the study, of whom half were female. The mean age (standard deviation, SD) was 27.2 (SD 8.1) and the ppFEV$_1$ was 62% (SD 22%), with a range of 31% to 101%. The mean (SD) body mass index (BMI) was 22.5 (4.3), and 16 (53%) were homozygous for Phe508del CFTR mutations. The median (IQR) of reported exercise was 0 (0–70), with 16 (53%) patients completing no exercise. Of the remaining 14 (47%), exercise ranged from 20–150 minutes. Further information is shown in Table 1.

Table 1: Baseline characteristics of RCT patients in groups A) Pactster and online physiotherapy support (OPS) and B) Pactster without online physiotherapy support.

Sample population	Pactster and OPS, *n* = 15	Pactster, *n* = 15	Total *n* = 30
Male, *n* (%)	8 (53%)	7 (47%)	15 (50%)
Age, mean (SD)	25.3 (5.3)	29.1 (9.9)	27.2 (8.1)
ppFEV$_1$, mean (SD)	59.4% (25.4%)	64.6% (19.1%)	62% (22%)
BMI, mean (SD)	21.2 (3.8)	23.7 (4.5)	22.5 (4.3)
Phe508del/Phe508del	6 (40%)	10 (67%)	16 (53%)
Phe508del × 1	7 (47%)	4 (27%)	11 (37%)
Gly551Asp × 1	2 (13%)	0	2 (7%)
Pancreatic insufficient	12 (80%)	11 (73%)	22 (73%)
CF Diabetes	3 (20%)	5 (33%)	8 (27%)
CF liver disease	2 (13%)	1 (7%)	3 (10%)
Ivacaftor monotherapy	2 (13%)	0	2 (7%)
Lumacaftor/ivacaftor	1 (7%)	2 (13%)	3 (10%)
Baseline exercise = 0 minutes	9 (60%)	7 (47%)	16 (53%)
Mean exercise, minutes (SD)	32.3 (50.6)	42 (50.2)	37.2 (49.8)

Of the 30 patients recruited, five did not provide any outcome data at the six weeks' assessment (see Figure 2). Nineteen reported engaging with the Pactster website and participated in the online videos over the six weeks.

In the group that received Pactster and online physiotherapy, 11 of 15 used Pactster. In the Pactster without online physiotherapy group, 10 of 15 used Pactster. The reasons given by trial participants for not engaging with Pactster included a preference for the gym, a desire not to interact with other CF patients, feeling too unwell, and a perception that the exercise types were unsuitable.

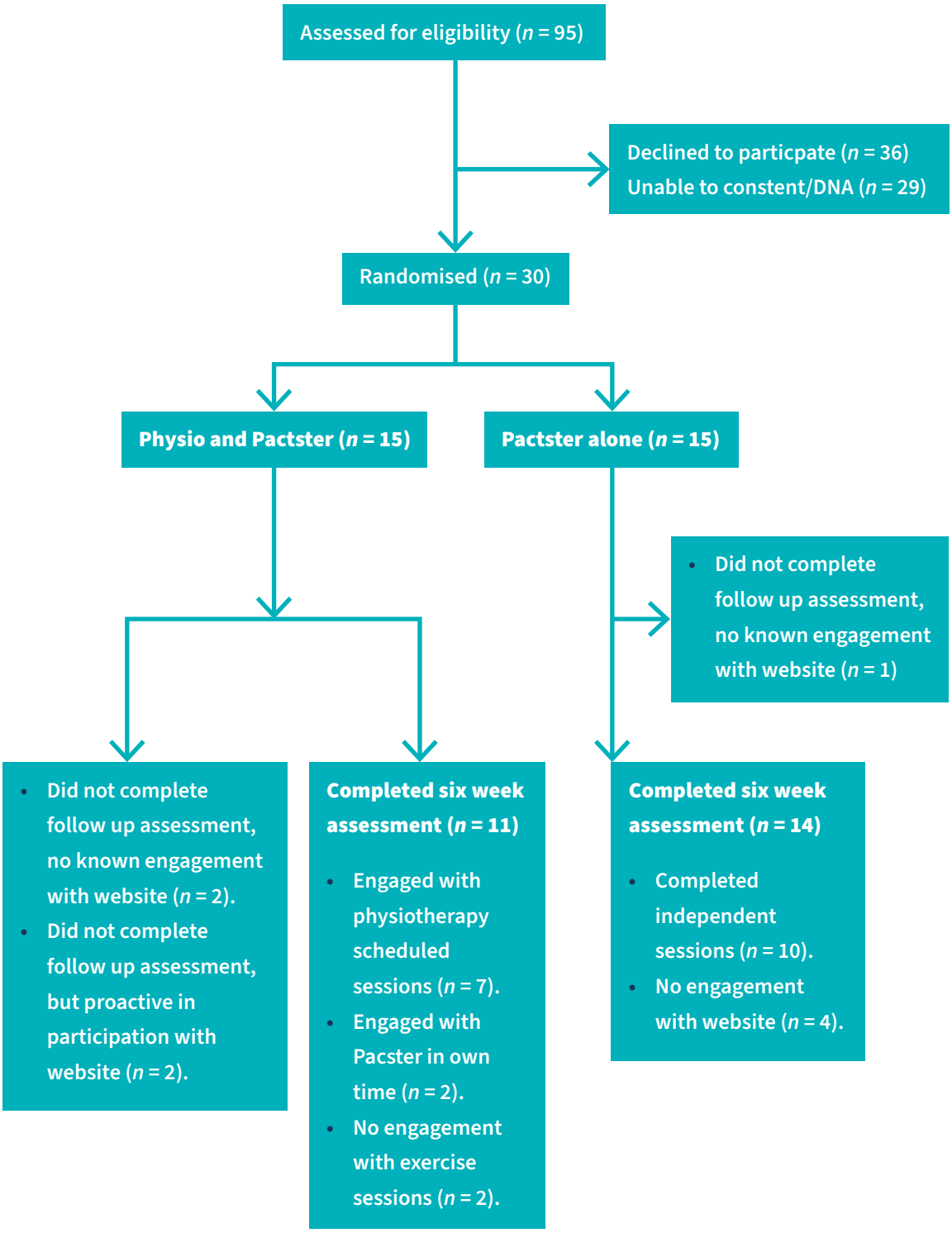


Figure 2: Consort diagram for eligible patients, with groups A) Pactster and online physiotherapy support (OPS) and B) Pactster without online physiotherapy support.

Primary outcome

25 patients reported that Pactster was acceptable (p <0.001), and five did not engage with follow up for whom we assumed it was unacceptable. Nineteen (63%) patients stated that they would like physiotherapy support, six (20%) stated they did not want physiotherapy support, and five (17%) did not answer.

For questions relating to the acceptability of Pactster, the median values were similar between groups though the median was numerically higher with physiotherapy input in terms of patients reporting how hard they worked (see Table 2).

Table 2: Acceptability of Pactster in groups *A* Pactster and online physiotherapy support (OPS) and *B* Pactster without online physiotherapy support.

Numerical scale 0–10 median (IQR)	Pactster and OPS	Pactster
How much did you enjoy the community aspect?	5 (5–8)	5 (4.5–5.5)
How likely are you to use Pactster in the future?	10 (7–10)	10 (7.5–10)
How hard were you working during the sessions?	10 (7–10)	5 (0–7)
Change in reported exercise minutes/week (week 6–0)	30 (20–180)	40 (0–60)

Secondary outcome

The change in ppFEV$_1$ was greater in the physiotherapy support group, with a between group difference of 6% (see Table 3). For the Chester step test, the change in average aerobic capacity and exercise time was greater with the physiotherapy group, though the between group differences were small. There were no between group differences with respect to the utility score, or the unadjusted or adjusted QALY scores.

Table 3: Difference between six week and baseline measures, groups *A* Pactster and online physiotherapy support (OPS) and *B* Pactster without online physiotherapy support.

Outcome: week 6–0	Pactster and OPS	Pactster
ppFEV$_1$, mean (95% CI)	+3.2% (-0.87%–7.2%)	-3.1% (-6.7%–0.45%)
Chester step test, aerobic capacity*	+3 (2–6)	+0.5 (-2.25–6)
Chester step test (time, minutes)	+1.5 (0–2)	0 (-1.6–1.25)
Utility score	-0.063 (-0.138–0.012)	+0.065 (-0.131–0.002)
QALY (unadjusted)	-0.0036 (-0.0080–0.00071)	-0.0037 (-0.0076–0.00013)
QALY (adjusted)	-0.0043 (-0.0087–0.00018)	-0.0032 (-0.0071–0.00068)

*Surrogate measure of aerobic capacity, mls O_2/kg/min.

Physiotherapy time

A total of 939 scheduled minutes of exercise were available to the participants in the physiotherapy group over the six weeks. There were 68 scheduled sessions in total, which ranged from 6–60 minutes in duration. 60 of the sessions were scheduled routinely with a morning

and afternoon option every weekday. Eight additional sessions were offered on Saturdays/evenings. Of all sessions offered, 591 minutes of exercise were completed by seven different participants. This underestimates engagement, as many performed their exercise independently. A total of nine participants reported completing the recommended sessions outside of the scheduled time slots at a time that was convenient to them.

Within the physiotherapy support group, a total of 32 posts were made in the Pactster Community by the physiotherapist over the course of the six weeks. Participants had phone support (45 minutes), email support (32 minutes) and 207 minutes of physiotherapy time utilised for online posting (messages of support) and scheduling of daily sessions. In total, 284 minutes (4 hours 44 minutes) of band six physiotherapy time was provided. Based on a cost per unit hour of £44 (€53) for a band six physiotherapist (which includes all add on costs such as management, estates, overheads for example)(15) the total cost was £208 (€250) over the six week period. Although it was observed that many of these duties did not require a band six physiotherapist, and that a band four physiotherapy associate practitioner would have sufficed (£137/€164).

Within the Pactster without online physiotherapy group, a total of 97 minutes of physiotherapy time was required to assist with sign up and to arrange follow up. This comprised of 25 minutes on the phone and 72 minutes in total emailing individuals with regards to confirming set up and a reminder about completing their exercise diaries. We included the latter in the physiotherapy time, as this prompt to remind patients to complete their exercise diaries may have inadvertently prompted exercise.

Quotations from questionnaires

Within the physiotherapy support group, the main feedback was that participants 'couldn't always engage with the sessions at the scheduled times', but despite this, 'appreciated the physiotherapy input and motivation' which encouraged them to complete the same sessions in their own time. It was felt the physiotherapy input was 'helpful to moderate and guide the use of the forum', but many did not feel it was necessary for them to interact with other users. It was suggested that 'once a week physiotherapy input would be a good incentive to encourage ongoing participation' as 'it is easier when someone tells you what to do'.

Although the Pactster alone group did not have access to online physiotherapy support, many felt it would be 'motivating to have the professional input', which could provide 'structure on what to do'. There was some hesitation in engagement in conversations with other members as the individuals 'did not know the other user's personal circumstances or backgrounds'. It was suggested that the 'Physiotherapist could help direct conversations'. One individual did comment however that they 'see enough physios and would prefer to do it themselves'.

Discussion

In adults with CF and low exercise participation, we have shown that an online, exercise platform is acceptable and is associated with an increase in weekly reported exercise, in those motivated to access exercise support. Online exercise supervision by physiotherapists may lead to improvements in lung function, and physical fitness; this may be as a result of increased effort given the higher levels of perceived exertion in the physiotherapy support group, however these results require replication in a larger, multicentre study, and should include a more objective measure of patient effort. The costs associated with providing online physiotherapy support appear to be acceptable, but require further examination in a health economic evaluation. In common with previous studies, exercise in this patient group appears to be safe, and there were no adverse events during the study period.

The study has several strengths. We have described the exercise practices of a large cohort of CF patients. Randomisation was performed by an external agency with allocation concealment to patients and researchers. Prior to the COVID-19 pandemic, there had been a lack of studies looking at the impact of physiotherapy input within online exercise programmes. It is now even more important to explore methods to reach our patient group remotely. Maintaining exercise adherence is challenging, and previous research suggests that supervision is associated with better outcome (9). Our exercise programmes were tailored towards the patient's needs and preferences, with classes for beginners, intermediate and advanced users across a range of activities for strength training, aerobic training, and mobility practices. This is important as a 'one size fits all' approach does not appear to be successful. We used multiple approaches to measure exercise participation, which included patient diaries, monitoring via the website and face-to-face and telephone interactions.

Key limitations were the short study duration and small sample size. This prohibits long-term habitual life-style changes and means that secondary outcome should be interpreted with caution. A larger, longer study should include measure of lung disease such as exacerbation frequency and consider full cardiopulmonary exercise testing. We measured aerobic capacity based on the patient's heart rate whilst performing the Chester Step Test. Whilst this cannot be taken as an accurate measure of the maximal oxygen uptake (VO_2 max), it correlates well with VO_2 max and is appropriate for tracking aerobic fitness due to its high test-retest reliability (14, 16, 17). The step test can be assessed in clinic, and the patient could undertake assessment at home at minimal cost and effort to monitor their own fitness. The Chester Step Test has been used via videoconferencing to remotely assess exercise capacity in CF (18) however further validation work is required in the CF population. Lastly, including the use of activity monitors would have added precision to measures of activity levels.

Use of online resources has been explored as a tool to increase exercise engagement (18, 19) but FEV_1 outcome has not been examined. Previous RCTs of traditional exercise

programmes (not online) showed a trend towards (8, 9) or a convincing improvement (10) in FEV_1 with exercise. These improvements do not appear to be sustained over time without supervision. This issue may be addressed with longer term online physiotherapy support, which our study suggests can be delivered at a reasonable cost, but require further study as the passage of time could primarily account for the drop-off in adherence, irrespective of support.

We measured the EQ-5D-5L to perform a health-economic evaluation to guide a future larger study. Despite potentially clinically relevant differences in lung function and exercise capacity, there was no between group difference in the utility scores. This may be due to a lack of efficacy of the intervention, or the EQ-5D-5L may lack sensitivity in this patient group.

Following completion of this study we have continued to value the use of online exercise platforms with virtual physiotherapy support, and this has been of particular benefit during the COVID-19 pandemic where face-to-face sessions were limited. Virtual exercise sessions and step testing are now part of usual care within the Newcastle Upon Tyne Adult CF Service, which has been well-received. A single Pactster community was created, and the ongoing intervention was successfully provided by a band four physiotherapy associate practitioner, which reduces cost. Our study was perhaps too short for patients to foster supportive online relationships with fellow patients that could help with adherence.

In the post COVID-19 and CFTR modulator era and the evolving face of CF care, the findings of this research are pertinent to the James Lind Alliance CF Research Priorities. In particular point six, 'what effective ways of motivation, support and technologies help people with Cystic Fibrosis improve and sustain adherence to treatment?' and point seven 'can exercise replace chest physiotherapy for people with Cystic Fibrosis?' (20). The information obtained could feed into larger studies to provide valuable information to the CF population.

This study has demonstrated the acceptability of online community exercise platforms such as Pactster (now operating under the branding BEAM for Cystic Fibrosis) as a method to encourage exercise participation in those with low levels of baseline exercise performance who are seeking to increase their exercise levels. Provision of physiotherapy support on the platform was well received by users, helps provide an appropriately tailored programme, and provides promising clinical results. This approach can be readily replicated by physiotherapy teams. This meets the CF patient requirement for segregation, and overcomes the geographical challenges faced by CF centres in providing ongoing, regular support exercise programmes at a reasonable cost.

Key points

- Patients with CF cannot exercise together due to the risk of cross infection.
- Online exercise platforms allow group exercise and virtual interaction.

- In this study, an online exercise platform is acceptable to 83% of patients.
- Additional online physiotherapy support may improve FEV_1.

Declarations of interest

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: C Echevarria reports grants from National Institute of Health Research, outside of the submitted work, and no competing interests in relation to this work. Rachael Bass, Stephen Bourke, Lisa Morrison, Lucia Diego-Vicente, Emma Hope, Laura Blanch, Sarah Lenaghan and Carlos Echevarria.

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Home monitoring and self-management for adult patients with cystic fibrosis during the novel coronavirus pandemic: a service evaluation in a specialist cystic fibrosis unit

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Keywords | Cystic fibrosis, home monitoring, coronavirus, spirometry, self-management.

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Abstract

Objectives

To determine acceptability and usefulness of home monitoring of weight and spirometry and a personalised action plan (PAP) in adults with cystic fibrosis (CF) and explore the effect on lung function and healthcare utilisation for four months during the COVID-19 pandemic.

Design

Service evaluation.

Setting

A U.K. based specialist adult CF unit.

Participants

Sixteen adult CF patients who had over 28 days of intravenous antibiotics in the preceding 12 months.

Interventions

Patients completed weekly readings at home of weight and spirometry on a NuvoAir spirometer and received a personalised action plan (PAP) that advised actions if their weight or lung function reduced.

Main outcome measures

Adherence to home monitoring, patient satisfaction, lung function, courses of intravenous (IV) and oral antibiotics.

Results

All patients found the home monitoring beneficial. Adherence to weekly monitoring was 38%. Fewer patients received IV antibiotics (8 versus 10) although the duration of IV antibiotics increased from 14.3 to 14.6 days. The number of patients requiring oral antibiotics also reduced (16 versus 10). The number of courses also halved from 1.6 to 0.8. Of the patients who received their action plan 75% found it useful and half of them used it to make changes to their treatments. There was no change in lung function.

Conclusions

Introduction of home monitoring and self-management was well received by patients. Antibiotic usage reduced without having a detrimental effect on lung function suggesting that the introduction of the home monitoring service potentially helped counter act the detrimental effects of a reduction in face-to-face clinic appointments due to the pandemic.

Introduction

In January 2020 the novel COVID-19 was detected in the U.K. The World Health Organisation declared a pandemic on 11th March. By 15th March there were over 1000 U.K. cases, and high-risk groups, including those with cystic fibrosis (CF), were advised to 'shield'; to remain inside to reduce infection risk (1). Telephone clinics replaced outpatient CF clinics; thus, lung function and weight were not being assessed. Clinic visits usually occur quarterly and are used to identify and treat pulmonary exacerbations. These cause long-term deterioration in lung function and poorer quality of life (2, 3) Our centre wanted to remotely monitor our highest risk patients and encourage them to recognise deterioration to help maintain the health of this vulnerable population.

Previous research in 267 patients with CF found that home monitoring significantly reduced the number of patients requiring intravenous (IV) antibiotics; 32% versus 52% in the control group, $p = 0.027$) and significantly reduced the number of hospitalisations ($p = 0.015$). Participants' lung function was not negatively impacted (4) indicating that introducing home monitoring for our patients, potentially, could be safe and beneficial.

The Air Next by NuvoAir is a portable spirometer with disposable turbines that does not require calibration. It links to smart phones via Bluetooth® and results are automatically uploaded to a website that can be viewed from the CF clinic. The validity of the Air Next spirometer has been assessed and a Pearson correlation coefficient of greater than 0.94 for both FEV_1 and forced vital capacity (FVC) has been demonstrated (5).

Weekly home monitoring of weight, symptoms and lung function may allow patients to remain at home, identify deterioration earlier and prevent decline in lung function. Patients with the greatest utilisation of healthcare in the preceding 12 months at our centre were

chosen to trial home monitoring because they were at greatest risk of clinical deterioration. Funding had been secured for 16 spirometers and weighing scales through a hospital 'change challenge' initiative.

To support the use of home monitoring written, personalised action plans (PAPs) were utilised. PAPs are written guidelines providing individualised self-management instructions. There have not been any studies looking into the use of action plans for patients with CF but are recommended by national guidelines for use by patients with asthma to help maintain control of their symptoms (6). A Cochrane review in asthma found a statistically significant improvement in quality of life and a reduction in days lost from work or study (7).

This report outlines the set-up, patient satisfaction and initial adherence with home monitoring. It also reports on healthcare utilisation at our centre four months before and after the introduction of the devices and lung function data at the start and four months into the home monitoring project. Use and patient satisfaction with the PAPs, termed a traffic light system, was also reported.

Methods

This service evaluation was registered with the research and development team at our hospital. They reviewed the project in September 2021, once they had reopened after COVID-19, and confirmed that it was a service evaluation and therefore ethical approval was not required.

Adults with CF who had >28 days of IV antibiotics over the previous year were offered the equipment. All patients who agreed, received the home monitoring kit, consisting of an Air Next spirometer (NuvoAir, Stockholm, Sweden) and a set of weighing scales (Seca 875, Birmingham, England).

The devices were distributed to patients during appointments, collected by the patients or by their relatives. Patients set up their device independently using emailed instructions. They measured their weight and spirometry and completed a four-item symptom questionnaire on the NuvoAir application (app) weekly. In the questionnaire the patient uses a five-point scale to score each of the respiratory symptoms of breathing, cough, mucous and chest congestion.

When the patient was stable, baseline measures were used by the specialist Physiotherapists to develop a PAP detailing the action needed if their health deteriorated (Appendix 1). This was named a traffic light system and was emailed to the patient. When the patient's lung function was stable, they were in the 'green' and no change in management was needed. A patient would score 'amber' if their lung function reduced between 5% and 10% of their symptom score and increased by one point and they had details on how to increase nebulisers and physiotherapy treatment and were advised to repeat lung function in three days. If their lung function dropped more than 10%, or their symptom score increased more

than two points, then a red light was triggered. Patients were asked to contact the unit that day and further increase their nebulisers and physiotherapy.

Adherence was assessed by calculating the dates that weekly tests were expected and comparing them to the actual test dates from setup until 10th June 2020. Percentage adherence was then calculated. An adherence target of 80% was decided as an acceptable value as this would allow for a few, expected weeks where patients were unable to complete measurements. It also mirrors the adherence target set by Lechtzin and colleagues in 2017. If patients had not competed either spirometry of symptom measurements in the preceding two weeks, then a reminder text message was sent.

The number of courses and days of IV antibiotics each patient received for 4 months before and after receiving their spirometer were assessed retrospectively from patient records. Lung function data was taken at initial set up and four months after setup on the Nuvoair and included FEV_1 and forced vital capacity (FVC). The measurement completed closest to the four-month date was used if the patient did not have a reading on the exact date. A mean value for FEV_1 and FVC was calculated between all patients and compared before and after the monitoring period.

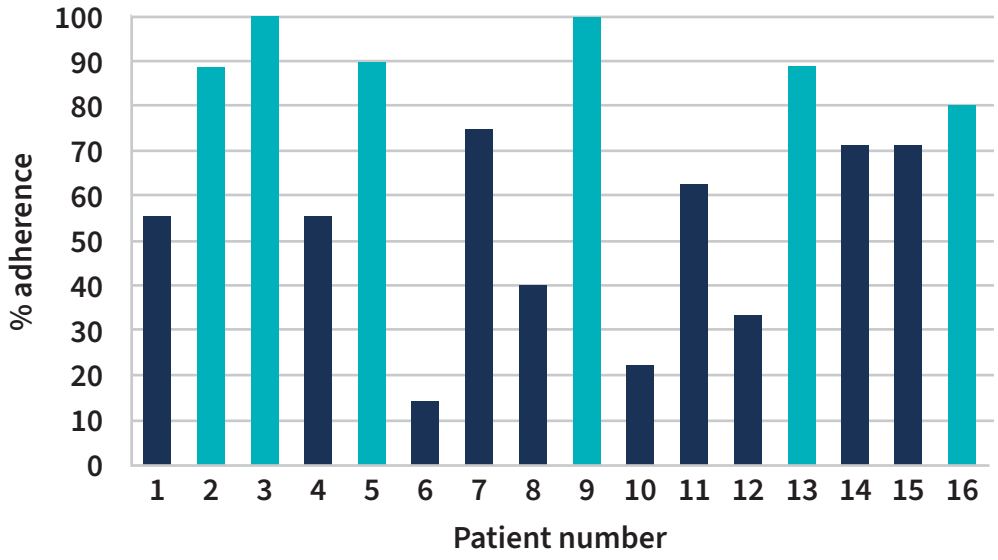
Patients' experience of the Air Next spirometer, the app and the traffic light system were assessed using a questionnaire in SurveyMonkey®. (Appendix 2) All 16 patients were sent an email link inviting them to complete it and a follow-up reminder text if they did not respond initially.

Results

22 patients were eligible but four were unable to collect the equipment, one declined for mental health reasons, and one declined without reason. 16 patients agreed to participate. Funding for the equipment was agreed on 13th March. The equipment was set up between 4th April and 11th May 2020. Half the devices were collected by the patient themselves (8/16). Three of the patients (19%) were on home IV antibiotics when they started monitoring at home. One of the patients went on to be admitted to hospital.

Adherence

Of the 16 patients, only six (38%) carried out the expected number of tests in the monitoring period (Figure 1).



Green = >80% adherence.

Blue = <80% adherence.

Figure 1: Adherence to weekly monitoring.

Lung function

Over the four-month period FEV_1 and FVC remained stable.

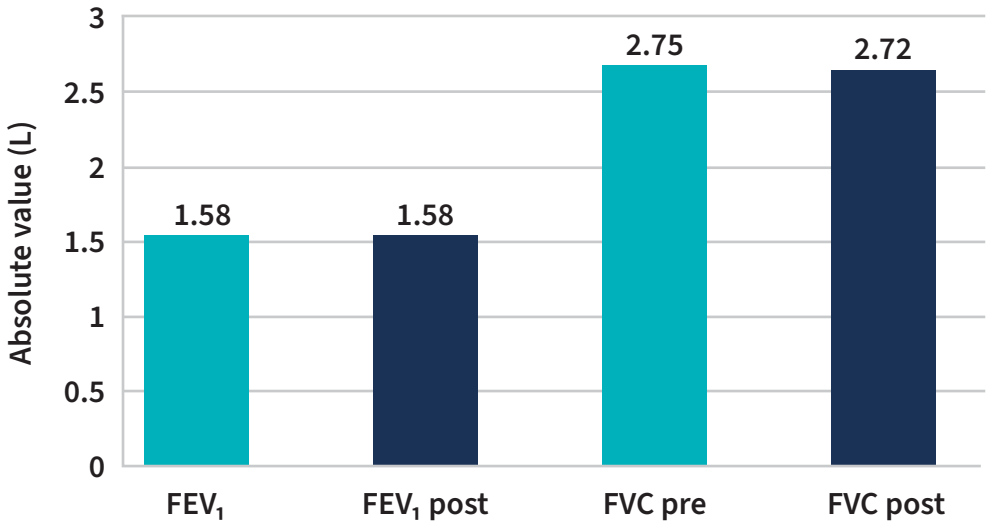


Figure 2: Lung function before and after home monitoring.

Antibiotic usage

Oral antibiotic usage reduced: 10 out of 16 (63%) patients had oral antibiotics compared with 14 patients (88%) before home monitoring. The average number of courses of oral antibiotics per patient also reduced from 1.6 prior to 0.8 after the home monitoring project.

The number of patients receiving IV antibiotics after the home monitoring project also reduced; 10 out of 16 (63%) patients had IV antibiotics before the project compared with only eight patients (50%) after (Figure 3). However, the average number of days of IV antibiotic

was higher after the introduction of home monitoring (14.3 days before versus 14.6 days after).

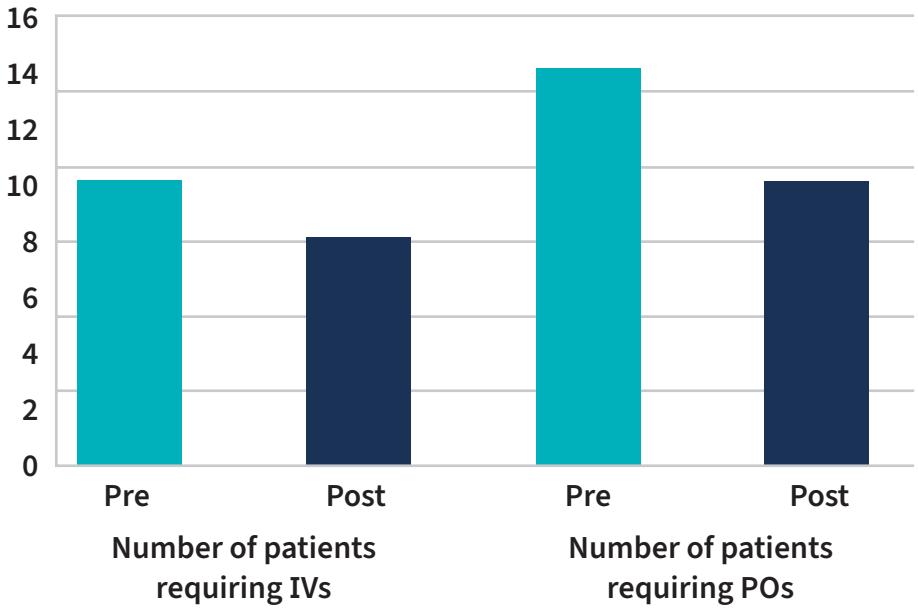


Figure 3: Number of patients requiring IV or per oral (PO) antibiotics before and after home monitoring.

Patient experience

Eleven out of 16 patients (69%) completed the survey. Nine of the 11 (81%) patients found it 'easy' or 'very easy' to setup and use the spirometer. One patient found it difficult because they found it difficult to pair to their phone.

All patients (11/11, 100%) found it useful to monitor their spirometry at home with 6/11 (55%) finding it 'extremely useful', 3/11 (27%) 'very useful' and 2/11 (18%) 'somewhat useful'.

An open question at the end allowed patients to comment on benefits and difficulties. (Tables 1 and 2).

Table 1: Patient reported benefits of the Air Next spirometer and app.

Benefit	Number of patients reporting
Ability to use at home	5
Easy to use	3
Looking at the trend in lung function	3
Not as stressful to complete spirometry at home	2
Used to check when unwell	2
Useful to monitor health	2
Quick to use	1

Table 2: Reported difficulties with the Air Next Spirometer and app.

Difficulty	Number of patients reporting
Nothing	3
Does not prompt you to change your weight before use	2
Unusual flow volume loop	1
App closes before the results are saved	1
Unclear comments about usage and performance	1
Not recording to results	1
Screen times out before the results are saved	1
Temperamental	1
The need to connect the device to their phone each time they use it	1
Stops reading before the patient has finished breathing out	1

Traffic light systems were received by 8 patients. Of these, 6 (75%) found it useful and easy to use. The other 2/8 (18%) found it 'neither easy nor difficult'. 4 patients (4/8, 50%) used it to make changes to their treatment. See Appendix 3 for more details of the survey results.

Discussion

This report details the setup and evaluation of a home monitoring service for adults with CF. Initial results were promising, with a reduction in oral and IV antibiotics, stable lung function and overall satisfaction with the service. The sample size in this report is small and therefore care needs to be taken when widening the use of home monitoring to the rest of our clinic patients. However, the patients chosen were the higher risk patients, therefore we have confidence to expand the service to include those in lower risk groups as well.

Only 73% of patients approached to participate in this service evaluation agreed to home monitoring, which was lower than expected. The main reason was an inability to collect the equipment. It was decided not to post the kits out due to the risk of patients not receiving the equipment. Adherence to weekly monitoring was also found to be low although all patients did monitor less frequently. Previous research found 50% adherence to weekly spirometry (4) but low patient numbers at our centre may explain the discrepancy.

The reason that data analysis was carried out at four months was because a new genetic modifier drug, Kaftrio, was started on a large proportion of the patients at the beginning of September. This drug has shown to reduce exacerbation rate by 63% (8). Therefore, any data collected after this time may have been affected by this.

The reduction in the number of patients requiring antibiotics was positive (Figure 3). However, patients were also 'shielding', so less exposed to respiratory infections. The patients who did require IV antibiotics demonstrated a small increase in the number of days that they required. This may be an effect of closer monitoring detecting changes earlier than their clinical presentation would. One patient was on IV antibiotics for an unusually high number of days, causing an anomaly in the data. However, removing the influence of their data reduced the number of days on IV antibiotics from 12.3 days to 9.1 days. Lechzin et al (4) also found an increased number of pulmonary exacerbations and a shorter time to first exacerbation. However, they found that patients were more likely to have oral antibiotics, rather than IV antibiotics. This was in contrast with our results. This may be because patients at our clinic, before home monitoring, would have started a 'rescue pack' of oral antibiotics if they were not feeling well, without contacting the clinic. Since the introduction of home monitoring, they would have been reviewed by the CF team if their lung function had reduced as well as reporting symptoms.

One of the limitations was that the symptom questionnaire used was not validated. The use of the CF Respiratory Symptom Diary (CFRSD) was considered, (9). However, there is a cost associated with its use and compliance would likely below. There was poor adherence completing the in-app measure, despite regular prompts to complete it through text message.

The traffic light systems were developed to increase independence. However, only eight out of 15 patients reported receiving them via email. This has highlighted a need to follow-up with patients to ensure that they have received the information. Only 50% of patients reported making changes to their treatments based on their traffic light system. The reason for the low usage is not clear: one patient did comment that they are used to assessing their own health requirements therefore did not find it beneficial. Others may have had stable lung function, therefore had no need to make changes to their treatment.

For support in rolling out the use of home monitoring wider, our unit has since received funding and has purchased 80 extra kits. Results are reviewed weekly and those triggering an amber or red light are discussed at the multi-disciplinary team meeting and outcomes documented. Self-management will also be encouraged by ensuring that patients have received their traffic light system and clinicians are regularly prompting patients to use them.

Conclusion

The response to the introduction of a home monitoring service was positive and patients that participated have found it beneficial. Antibiotic usage was reduced, and lung function was maintained, indicating that it may have helped counteract the detrimental effects of a reduction in face-to-face appointments. This service evaluation has shown that it is safe to expand the service to more patients and will help to monitor the effects of the new medication, Kaftrio.

Key points

- Home monitoring was well received by our patients and all patients found it useful.
- Antibiotic usage reduced in the study period, but lung function remained stable.
- Patients found the self-management plans useful, and half the patients used them to make changed to their treatments in the study period, when previously they may have called the unit for advice.

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Attendance and completion of cardiac rehabilitation following heart transplantation: a survey service evaluation from the referring transplant centre

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Keywords | Attendance, cardiac rehabilitation, heart transplant, exercise.

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Abstract

Background

The transplant physiotherapy team at the Royal Papworth Hospital refer all patients who have undergone heart transplant to their local cardiac rehabilitation service on discharge from hospital. Due to the nature of being a tertiary centre, little to no feedback is received on patient attendance and completion.

Objectives

The aims of this work were to find out whether our patients are attending and completing their cardiac rehabilitation programmes and if not, then investigate the reasons for non-attendance/completion.

Methods

The cardiac rehabilitation centres responsible for the care of the 25 heart transplant patients operated on in the six-month period; January 2019–July 2019 were contacted; This totalled 21 individual centres.

Each centre was asked:

- Did the patient attend?
- Did the patient complete the course?
- Why did the patient not attend?
- Why did the patient not complete the course?

Results

Out of the 21 centres contacted 18 responded; caring for 22/25 of our patients; and results showed that at six months post discharge from hospital only 32% of our patients operated on between January 2019–July 2019 had attended and completed cardiac rehabilitation. No data was collected for the remaining three patients due to lack of

response from the three centres responsible for their care following email and telephone attempts.

Discussion and conclusion

Better long-term outcomes post heart transplant are achieved through maintaining a consistent exercise routine as well as keeping a moderate level of fitness. An attendance rate for CR of 32% will never be an acceptable rate however, further service improvement could be done to improve the engagement of potential CR users and ensure better attendance rates in the future.

Introduction

The benefits of exercise on cardiovascular health are well documented both in the prevention of health deterioration and in the recovery of post-operative patients (1). One of the biggest risks post-discharge following heart transplantation is rejection, which can occur at any time during the patient's post-operative lifetime. Five years following heart transplant one third of patients are diagnosed with cardiac allograft vasculopathy (CAV) this increases to >50% after 10 years (2). Due to graft denervation CAV does not present with angina pain; instead, first clinical presentation may be heart failure or sudden cardiac death. Treatment of established vasculopathy is poor so focus is currently on early identification and prevention (3).

CAV alone accounts for 10% of deaths in the heart transplant population per year and current evidence suggest exercise plays a big role in both preventing this complication and in its early detection (4). During the transplantation procedure the sympathetic and parasympathetic pathways are severed; this denervation causes a loss of efferent and afferent nerve signalling into and out of the heart. Due to this the transplanted hearts response to exercise is deranged in multiple ways; slower increase in heart rate; to a lower heart rate max; with a longer time to return to a baseline heart rate; that is higher than a normal heart rate at rest (5).

Reinnervation can occur in 40–70% of heart transplant patient late after their surgery however is often unbalanced and can differ between persons. Reinnervation of the sympathetic pathways can occur at 5–6 months post-operatively but is more likely to occur at 18 months post-operatively. The parasympathetic pathway can be reinnervated as early as 3–6 months post-transplant but mostly occurs around two years. Sympathetic reinnervation can occur without parasympathetic reinnervation, but the latter seems to appear only in sympathetically reinnervated recipients. Cardiac reinnervation is highest in the left antero-basal wall of the heart and lowest in the septum and sinoatrial node regions; this is also described as being highest in the left anterior descending territory; followed by the left circumflex territory and lowest in the right coronary artery territory (5). Exercise at a moderate to intense

physical training could improve the state of cardiac re-innervation as shown by improving heart rate variability (HRV) (5).

Current clinical referral pathway

At Royal Papworth Hospital (RPH) in Cambridge current practice is to refer heart transplant patients on to their local cardiac rehabilitation (CR) team for ongoing exercise prescription and monitoring post-discharge. Prior to discharge the physiotherapist responsible for the care of the patient will contact the local team and discuss whether the referral will be accepted; unfortunately, some centres still do not accept heart transplant patients. It is not reported in the literature why some centres do not accept this patient group though anecdotally it would appear to be around funding, expertise, and experience. Those patients who do not have access to a CR service due to the speciality of surgery performed, are given an exercise programme on discharge with advice on how to progress, though they are expected to complete this autonomously. Following this, a personalised letter is sent to the CR team with a full handover of the patient's hospital stay, exercise capacity on discharge and precautions to adhere to whilst exercising. Within the report there is clear guidance on the safe prescription of exercise in this population given the severance of the vagal nerve during the surgical procedure. Once this referral has been accepted and supporting information sent, physiotherapy care is handed over to the cardiac rehabilitation team and no further routine contact is made from RPH physiotherapy department. Input is provided to patients at RPH if required in out-patient clinics or as an inpatient if readmitted; it is presumed that they attend and complete their CR course; currently it is not known by the referring centre whether these patients do as expected or whether they continue to adhere to exercise afterwards.

The aim of this service evaluation was to (1) investigate whether people that have had heart transplants and have been discharged from RPH have attended and completed CR by six months post-discharge and (2) to ascertain the barriers preventing participation and adherence to CR.

Methods

All patients referred to CR in the six-month period from January 2019–July 2019 were reviewed. 25 patients who received heart transplants at Royal Papworth hospital between these dates were referred to 23 different CR centres. These centres were contacted via email and a follow up telephone call if no response was received via email; the centres were identified from the referral forms sent that are kept by the RPH Physiotherapy team in a secure folder.

Each centre was emailed via the contact details found on the British Heart Foundation CR Finder tool (6) and asked the following four questions:

- Did the patient attend?
- Did the patient complete the course?

- Why did the patient not attend?
- Why did the patient not complete the course?

Using the *Health Research Authority Decision tool*, it was deemed that ethical approval was not required for this service evaluation (7). Research and Development approval was requested and granted by the research and development team at the Royal Papworth Hospital.

Results

Responses for 22/25 patients were received; three centres did not respond when contacted accounting for the three patients for which responses were not received. At six-months post discharge from hospital only 32% ($n = 7$) of heart transplant patients operated on at RPH between January–July 2019 had attended and completed CR.

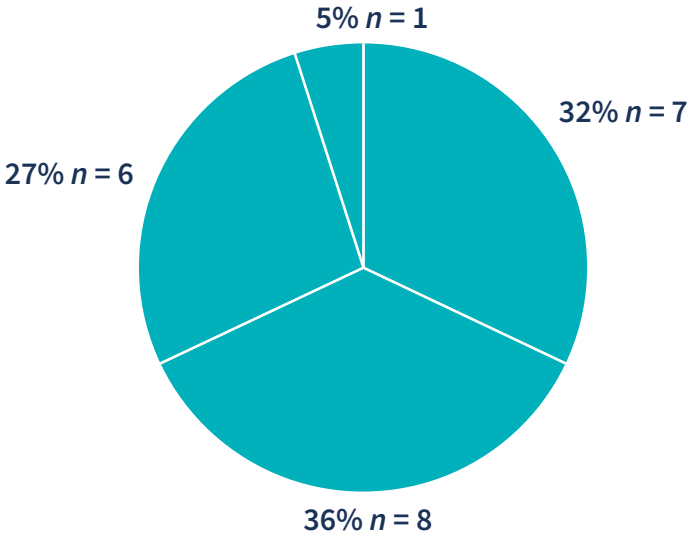

Figure 1: Percentage of patients attending and completing cardiac rehabilitation.

Figure 1 shows that 32% ($n = 7$) of patients had attended and completed CR; one patient still being on the waiting list; and 63% ($n = 14$) of patients had not completed a CR course at six months post discharge from hospital; this is summised by adding those that did not attend at all; 27% ($n = 6$); with those that attended but did not complete the course; 36% ($n = 8$).

Six (27%) patients did not attend CR at all within the first six-months post discharge from RPH. Reasons for non-attendance included: Unable to contact ($n = 3$), post-operative complications ($n = 1$) and preference of having a home exercise programme ($n = 2$).

Discussion

It is known that better long-term outcomes post heart transplant are achieved through maintaining a consistent exercise routine as well as keeping a moderate level of fitness (4–5). Government recommendations of 30 minutes of moderate to intense exercise five times a week for a healthy adult are often used as a target (8). From the information collected from this service evaluation it is was found that in a 6-month period only 30% of the

patients that had a heart transplant had completed cardiac rehabilitation; due to the means of data collection it was difficult to ascertain a reason as to why adherence had been poor. Although the total number of patients was low; this still accounts for the total caseload of heart transplant patients for this period at the Royal Papworth Hospital. It is important to consider a patients access to CR as this is not consistent across the country; in some cases the cardiac population do not have access to CR and are unable to be offered CR post heart transplant.

Information regarding why follow-up was inconsistent across the different CR centres when contact was lost or lack of attendance from, patients could have been explored and why some patients were not referred when moving out of area should have been collected which does present a limitation of this service evaluation. Future work could explore the patient perspectives of adherence to completing the full course of CR. The impact of attendance during/following the post-transplantation medical optimisation period could also be further analysed; during this time; the medical team work with our patients to optimise immunosuppressant's, anti-rejection medications and stabilise any complications that may have arisen post operatively. Investigation of other forms of exercise or physical activity whether this is formally prescribed exercise, activities of daily living or otherwise would be beneficial. Further exploration into these areas could provide more options for the patient to be able to adhere fully whilst still being able to adapt their lifestyle around this life changing time. It is hoped that this could highlight the need for further research looking at why patients may not consistently engage in CR post heart transplant leading to poor completion levels at six months post discharge; further service evaluation exploring the benefits and limitations of a telephone follow-up service could also provide further information to guide clinical practice on the best way to support this patient group post-discharge to engage with and furthermore complete CR.

Conclusion

In conclusion 30% will never be an acceptable rate of attendance to CR however, further service improvement could be done to improve the engagement of potential CR users and ensure better attendance rates in the future. As the referring centre it is vital we can improve engagement and understanding of the importance of CR following heart transplantation. It is essential that patients are provided with adequate follow-up to ensure that access to and adherence to a long-term exercise programme is met. In doing this, early identification of rejection, prevention of long-term co-morbidities as well as a healthy lifestyle may be achieved furthermore reducing mortality rates and improving quality of life in this patient group.

As a result of this information, the RPH Physiotherapy team responsible for the care of transplant patients have implemented a telephone follow-up service at six weeks and six months post discharge to review exercise routines and support further with referrals.

Further data is being collected to see whether this is sufficient or whether face-to-face or virtual follow up meetings would provide better adherence and outcomes. The physiotherapy team have implemented this as an appropriate service to support the aftercare of the RPH heart transplant patient group and therefore individual CR centres have not been informed of this.

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Chest infection incidence in wind musicians: a survey

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Keywords | Respiratory tract infections, wind musicians, instrument hygiene.

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Abstract

Objectives

Presence of microbes in wind instruments potentially increase the risk of wind instrument musicians (WIMs) developing chest infections (CI). Research investigating any relationships between WIMs and rates of CIs is scarce. This study primarily investigated the incidence of CIs in a group of U.K. WIMs compared to the U.K. general population. Secondary aims explored the WIMs instrument cleaning practice and investigated their knowledge of CI symptoms.

Design

A bespoke questionnaire was distributed to one U.K. university's wind instrument orchestra auditionees. Participants were included if over 18, of at least grade eight (musical) standard and if they practiced at least four hours per week. Quantitative responses were analysed using descriptive statistics and qualitative responses were thematically analysed.

Setting

One university in England.

Participants

52 questionnaires were completed. Mean ± SD or percentage (%) age 20 ± 1 years, gender 54% female, primary instrument 44% flute and 31% saxophone, diagnosis of asthma 23%.

Outcome measures

Questionnaire of self-reported number of CIs in previous five years, frequency and descriptions of cleaning instruments and knowledge of CI symptoms.

Results

An increased incidence of 62 CIs per 1,000 adults per year was reported compared to the U.K. general population of 49–54 per 1,000 adults per year. Thirty one percent (n = 16) reported least CI in the previous five years. 48% (n = 25) cleaned their instruments every time after playing and 58% (n = 30) had never been taught cleaning methods. Only 2% (n = 1) were able to correctly identify all five CI symptoms stated in the questionnaire.

Conclusions

WIMs had an increased incidence of CIs compared to the U.K. general population. Instrument hygiene and knowledge of CI symptoms was poor. Further investigation on a larger scale would build on these findings.

Introduction

According to Marshall et al (1), up to 100% of musical instruments harbour bacteria, mould and/or yeast, and reed instruments (for example, clarinet, oboe, bassoon) fair worse in density of microbes present than flutes or trumpets due to the reed of the instrument. Reeds cannot be wiped dry and sanitised due to the natural material of the reed and the risk of potential damage when cleaning. Not systematically drying an instrument after playing significantly increases the number and total concentration of fungi present (p <0.05) (2).

The survival of potentially pathogenic bacteria applied to reeds has been investigated (1). All species of bacteria persisted for a maximum of 24–48 hours except *mycobacterium* which survived over 13 days. *Mycobacterium* has been linked with hypersensitivity pneumonitis (HP) (3, 4).

The first documented evidence of HP in a wind instrument musician (WIM) details a case study of suspected 'saxophone lung' in 1988 (5). A 67-year-old saxophonist displayed a two-week history of dyspnoea, coughing and chest tightness. No pathological reasoning for his symptoms were identified until the saxophone mouthpiece was cultured, revealing the presence of fungi (*candida albicans*, *candida famata* and *cryptococcus*). Following treatment, the saxophonist recovered and had no reoccurrence of symptoms since washing the mouthpiece with soap and water regularly. Further cases of HP in WIMs in the bassoon (4), bagpipe (6), trombone (3) and further saxophonists (7) have been published.

Blood samples from WIMs were obtained to detect specific antibodies against potential microbes present in wind instruments. 80% of WIMs had antibodies consistent with the microbes present in their instruments (2). Antibodies were significantly more present in WIMs than in healthy non-exposed controls (p <0.001) (2).

To prevent the survival of microbes in wind instruments an effective cleaning regime is recommended (2). Existing cleaning guidelines recommend that the mouthpiece of a wind instrument should be brushed 15 times within 30 seconds using a detergent or sanitiser solution to reduce microbial load (8). Soumagne et al (2) reported that just 13% ($n = 5$) of 40 wind musicians used a detergent or sanitiser after playing. There are currently no standardised guidelines for instrument hygiene.

Considering the evidence that wind instruments provide an environment for the growth of microbes that could lead to a chest infection (CI) (1, 2, 3, 4, 5, 6, 7, 8) WIMs should be aware of their potential increased risk.

A CI is classified as acute bronchitis (inflammation of the bronchi) or pneumonia (inflammation in the alveoli) (9). Overall incidence of community-acquired CIs is 49–54 per 1000 adults per year in the U.K. (10, 11).

Therefore, in this research study we investigated the incidence of CIs in a group of WIMs in the U.K. and compared our findings to the U.K.'s general population. Secondary aims were to investigate knowledge of CI symptoms and to explore their instrument cleaning practice.

Method

Sample

All students auditioning for a university wind instrument orchestra in Nottingham were invited to participate in a questionnaire. Inclusion criteria was any auditionee over the age of 18, of at least grade eight (musical) standard that practiced a minimum of four hours per week. Participants were excluded if they did not have English reading and writing skills.

Questionnaire and data collection

A bespoke questionnaire was designed with four domains (demographic, incidence, instrument hygiene and knowledge). Incidence asked participants to recall how many CIs they had been diagnosed with (by a general practitioner) in the previous five years. Instrument hygiene consisted of how frequently a participant's instrument was cleaned, the method of cleaning and instrument cleaning education they had received either by a teacher, manufacturer, or other source. Knowledge included asking the participants to identify the main symptoms listed associated with a CI (such as 'persistent cough' or 'increased temperature') and increased risk groups listed (such as 'pregnant women' and 'those with weakened immune systems'). The questionnaire contained open and closed questions. Ethical approval was granted by the University of Nottingham Medical School Ethics Committee (reference number: 58-1807).

A pilot study was completed on eight individuals (previous members of the university wind instrument orchestra). Data gathered from the pilot study was not included in the final analysis but used to inform the final version of the questionnaire. The feedback from the pilot study was to reorder the groups at risk of CIs so that it was not a leading question.

An information sheet and questionnaire were distributed to potential consenting participants following their audition and volunteers were asked to complete the questionnaire a quiet room. Participants were asked to post their completed questionnaires into a collection box; consent was assumed if they completed the questionnaire and posted it in the collection box. Potential participants were advised on the information sheet that their participation was voluntary, and all data anonymous.

Analysis

Data was inputted into computer password protected documents. Data was stored until the study was completed, and then destroyed. Data was analysed using SPSS and Microsoft Excel version 1812. Relationships between diagnosis of asthma and CIs were completed with Pearson correlation and were reported as weak, moderate or good. Incidence of CIs was compared to the U.K. general population. The text from open questions was subject to thematic content analysis using Braun et al framework (12) to identify themes from participants. Thematic analysis involved six steps: familiarisation with the data by line-by-line analysis (HD), generation of initial codes (HD), identification of themes (HD) identified themes were approved and discussed with another researcher (HD and KH), each theme was defined and refined (HD and KH) and themes written up (HD).

Results

54 surveys completed (response rate 92%) and two excluded (due to participants being below musical grade eight standard). All questions were completed (question completion rate 100%).

Demographics

The mean ± standard deviation age of participants was 20 ± 1 years and 54% were female. Table 1 highlights the most frequently played instrument was the flute. 23% of participants had a diagnosis of asthma confirmed and managed by their general practitioner.

Table 1: Frequency of wind instrument played.

Instrument played	*n*
Flute	23
Saxophone	16
Clarinet	13
Trumpet	6
Oboe	5
Trombone	4
Tuba	3
Cornet	3
Bassoon	3
Piccolo	2
Other	5

Incidence of CI

The mean number of CIs reported was 0.9 for the 54 participants. 31 percent ($n = 16$) reported experiencing at least one CI in the previous five years as diagnosed by their general practitioner and prescribed antibiotic treatment, see Figure 1. The mode and median number of CI reported was zero.

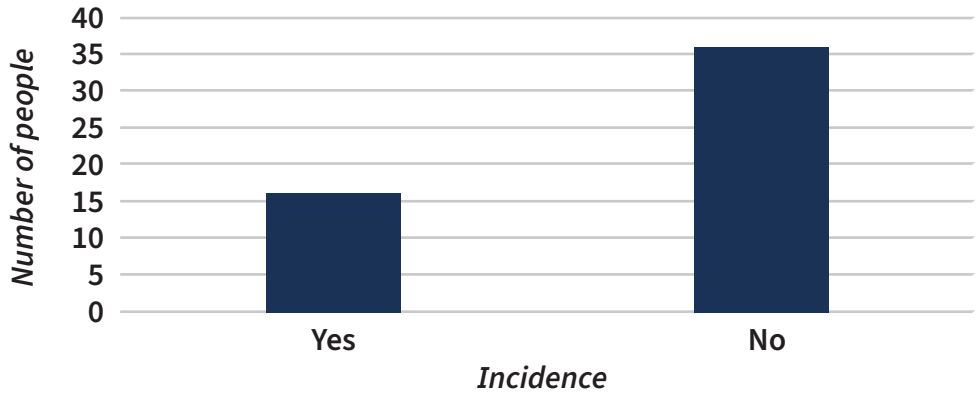

Figure 1: Incidence of CI in previous five years.

A weak relationship existed ($r = 0.03$; $p = 0.83$) between having an asthma diagnosis and at least one CI in the previous five years. A weak relationship existed ($r = 0.11$; $p = 0.46$) between having an asthma diagnosis and the number of CIs reported in the previous five years.

Wind instrument hygiene

48% of participants reported cleaning their instrument following each play ($n = 25$), see Table 2. The most frequently reported method of cleaning was a pull through cloth ($n = 36$, 69%), followed by bathing the instrument ($n = 11$, 21%) (see Table 3 for example responses). Only 42% ($n = 22$) respondents had been taught how to clean their instruments.

Table 2: Frequency of instrument cleaning reported.

Frequency	*n*	%
Following each play	25	48
Every other play	4	8
Weekly	5	10
Fortnightly	1	2
Monthly	7	14
Less frequent	10	19

Table 3: Example responses for method of cleaning themes.

Theme	Number of respondents	Example responses (subject number)
Pull through cloth/feather cleaner	$n = 36$	6: '*cloth through oboe*'. 18: '*cleaning rod and cloth through flute after use*'. 41: '*pull a cleaning cloth through each part*'.
Bathe instrument	$n = 11$	7: '*warm water, no soap. Soak and clean all tubing*'. 34: '*usually bathe in lukewarm water with some soap*'. 49: '*put trumpet in the bath to wash out tubes*'.

Knowledge

Each respondent could correctly identify a minimum of two CI symptoms listed in the questionnaire. Only one respondent (2%) could correctly identify all seven symptoms listed in the questionnaire. The most frequent correctly identified symptom was 'persistent cough' ($n = 50$, 96%), followed by 'coughing up yellow/green phlegm' ($n = 43$, 83%). The most frequent incorrect response was 'shivers' ($n = 20$, 39%).

Wind instrument musicians were identified by 39% ($n = 20$) of respondents at being potentially at increased risk of a CI, despite the survey investigating this issue.

Discussion

This questionnaire reported that 31% of experienced at least one CI in the previous five years. Less than 50% clean instruments following each play and 39% of participants reported that WIM were at an increased risk of CIs.

Incidence

No literature to the researchers' knowledge investigates CI incidence. In the general U.K. population, community-acquired CIs occur in 49–54 per 1000 adults per year (8, 9). In this study, 31% of participants reported at least one CI in the previous five years. To compare this with the general U.K. population, this could calculate at an average of 62 per 1000 adults per year.

Wark (10) and NICE (11) are based on the general U.K. adult population including groups at increased risk of a CI, whereas this research study only included those aged 18–24, making it difficult to compare as the populations have different characteristics. It is known that groups including the elderly and pregnant women are at an increased risk of CIs (11), and this research study did not include these groups. Therefore, it could be argued there is a further increased incidence of CIs in the respondents of this questionnaire, as there are fewer people who would be considered at increased risk compared to the general adult population.

Recent studies (1–2) reported the presence of bacteria, mould and fungi in instrument mouthpieces, which may have the potential to cause CIs. Theses microbes can enter the body and trigger an immune response, causing WIMs to have antibodies consistent with the microbes present in their own instruments (2). Clinically, this means WIMs may have to seek treatment for CIs that could have been prevented by systematic cleaning. Therefore, clinicians should ask patients during a subjective examination if they are a WIM to exclude a potential factor causing their respiratory condition (7, 8, 13).

Wind instrument hygiene

There are no studies investigating the frequency of instrument cleaning and no standardised cleaning guidelines for frequency or method of cleaning. Walter et al (8) recommended cleaning after each play with a brush and sanitiser to minimise bacterial count, whereas Soumagne et al (2) recommend regular cleaning and systematic drying of the instrument. In this study 48% of participants reported cleaning their instruments 'following each play' and 69% used a pull through cloth to clean and dry their instrument. This suggests that despite recommendations to dry wind instruments after use (2) and clean following each play (8) many do not, leaving them at an increased risk of microbe inhalation (1, 2, 8).

No research was found on teaching WIMs methods of cleaning. 58% of participants in this study had never been taught a method to clean their instrument, despite this being a music teacher's responsibility (14). Consideration of standardised cleaning guidelines and health education in instrumental lessons is recommended.

Knowledge

83% of participants identified 'yellow/green phlegm' as a symptom of a CI, compared to 48% of those with COPD with no prior education (15). As the characteristics of these populations are different, it is difficult to compare the groups, but it is the only available comparator.

Only 39% of participants identified that WIMs may be at an increased risk of CIs. There is no existing evidence investigating CIs in WIMs and WIMs may not be aware of the microbes that may be present in their instruments (1, 2).

Strength and limitations of the study

One strength of this research was the response rate of 92% which would be considered 'excellent' (16). Furthermore, the question response rate of 100% prevented non-response question surveys being excluded, therefore increasing the number of respondents included in the results.

This research study has potential limitations that could be addressed if this study was replicated. Only one university WIM population was surveyed, therefore results should be generalised to other WIM populations with caution. The participant information page stated the aim of the study for ethical reasons, so participants may have reported an increase in their incidence of CIs and reported that WIMs were at an increased risk of CI due to demand characteristics.

Conclusion

While the findings cannot be generalised to all WIMs, the incidence of CIs in this population of WIMs exceeded that of the general U.K. population. Sixty two CIs per 1000 people per year were reported in WIMs compared to the U.K. general population of 49–54 per 1000 people per year (10, 11). Furthermore, knowledge of CI symptoms was lacking. Hygiene practice among this WIM population did not meet recommendations given in previous studies and the majority had not been taught methods to clean their instrument(s). The findings demonstrate a need for standardised cleaning guidelines for instruments.

Further research should consider investigating the incidence of CIs in WIMs on a larger scale compared to a control group, with both amateur and professionals at varying ages and locations.

Key points

- Wind instrument musicians in this sample had an increased incidence of CI's compared to the U.K. general population.
- Instrument hygiene and knowledge of CI symptoms was poor in this sample.
- Standardised cleaning guidelines for instrument cleaning would be beneficial.

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Conflict of interest

No conflict of interest.

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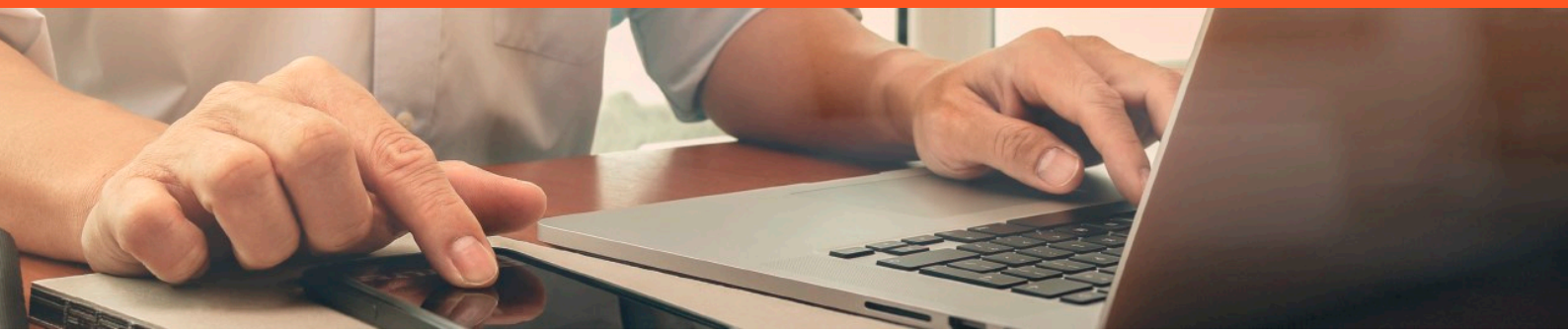

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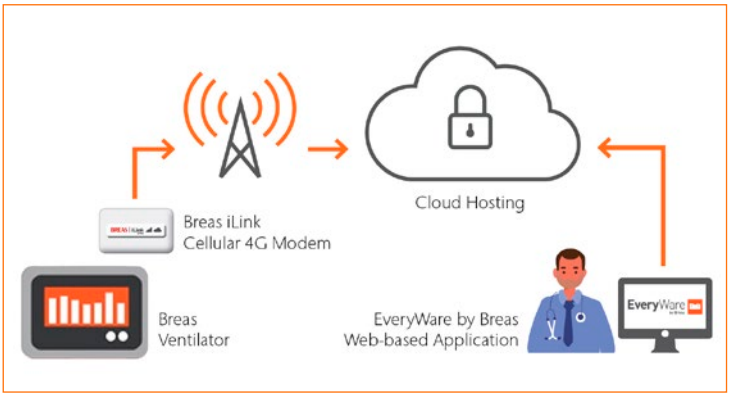

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BREAS

The role and staffing of physiotherapy in critical care: a scoping review

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Keywords | Physiotherapy, critical care, staffing, workforce ratios, roles, responsibilities.

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Abstract

Introduction

Physiotherapy services are provided to critical care units across the U.K. and internationally. U.K. guidance documents highlight potential physiotherapy roles and recommended staffing levels. However, this guidance is based on limited evidence and this scoping review was needed to inform workforce planning and future recommendations.

Objectives

The objectives of this scoping review were to:

- Map the volume and nature of evidence in relation to physiotherapy in critical care.
- Describe the role of physiotherapy within critical care.
- Describe recommended physiotherapy staffing ratios in critical care.

Methods

Available literature between January 2009–December 2021 was searched utilising relevant databases. Studies focusing on the role of physiotherapy or physiotherapy staffing levels were included. Data extraction and appraisal was performed using relevant Joanna Briggs Institute proformas.

Results

A total of 1121 titles were screened, with 22 full text papers reviewed. Studies were commonly based in South Africa and United States of America and were survey based (n = 16, 72%). Literature available to define the role of physiotherapy in critical care was limited, which was further complicated by variation of practice across countries.

Variability was observed for existing physiotherapy staffing levels ranging from 1:4 to 1:50 critical care beds.

Discussion

Based on our findings, there is limited evidence to define the role of physiotherapy within critical care, with widespread variation in existing staffing levels. Further research is required to define the role of physiotherapy in critical care and identify appropriate staffing levels in the U.K., including a focus on patient outcomes.

Introduction

The National Guidelines for the Provision of Intensive Care Services (GPICS v2) (1) identify physiotherapy as one of the principle and most consistent therapy services for critical care. Historically, the aim of physiotherapy was to maintain bronchial hygiene for people who were intubated (2), and while this remains a key area, the focus is now towards early rehabilitation and on physical recovery (3, 4, 5).

GPICS (1) recommends that across the U.K., there should be access to, and provision of, for patients in critical care 24 hours a day, seven days per week (1) and may be achieved through the provision of out-of-hours or on-call services and weekend working. Additionally, GPICS recommend physiotherapist to patient ratios of one physiotherapist to every four patients (1). Furthermore, it suggests possible roles to be undertaken by physiotherapists working in critical care, including providing assessment and intervention for a range of acute and chronic respiratory pathologies, promoting early mobilisation and preventing deconditioning during periods of acute illness, in addition to providing specialist rehabilitation following critical illness or severe injury (1).

Whilst these guidelines have been invaluable in advising service standards, audit and future planning, there is limited evidence to either support or counter the recommendations made. Several authors have explored the minimum standards of clinical practice required within critical care (6, 7, 8). These studies identified the key assessment and treatment skills and knowledge required to work as a physiotherapist within critical care. Within the U.K., 107 items were deemed essential as a minimum standard of clinical practice and concluded that the findings may support training programmes in both higher education and the health service, to reduce variability in clinical practice (7). However, given the 'minimum standards' criteria of previous literature, these are unlikely to fully reflect the role of physiotherapy in critical care, nor do they allow guidance of required staffing numbers or structures.

There is a clear need for the role of physiotherapy within critical care to be better defined, both within the U.K. and internationally.

Based on the above, the objectives of this scoping review were to:

1 Map the volume and nature of evidence in relation to physiotherapy in critical care.
2 Describe the role of physiotherapy within critical care.
3 Describe recommended physiotherapy staffing ratios in critical care.

Methods

Review objectives and questions

The *population*, *concept* and *context* approach (9) was used to develop the search strategy, with the following criteria:

Objective

To identify the roles and required staffing for physiotherapy services within critical care.

Review questions

1 What is the role of physiotherapy within critical care?
2 What quantity of physiotherapy staffing is required within critical care?

Population

Physiotherapists and physiotherapy services within critical care units.

Concept

Literature that broadly describes either the role of the physiotherapist or makes recommendations on required staffing levels, including any attempt to increase physiotherapy staffing or involvement.

Context

All adult critical care units, including tertiary services, in any nation.

Eligibility criteria

Articles focused on adult critical care units, available in English language and published during or after 2009 were included. The review period was based on the publication of guidelines for rehabilitation after critical illness (3). All relevant clinical articles were included, and expert opinion papers, clinical guidelines and surveys were also eligible for inclusion. For systematic reviews, relevant research papers were extracted and added to the existing search titles following the same inclusion criteria. To ensure focus on roles and staffing, studies that investigated the effectiveness of physiotherapy interventions in critical care was excluded as were papers focusing on the interventions for single pathologies including COVID-19.

Search strategy

Searches were completed using MEDLINE, CINAHL, Cochrane Library and PEDro (Physiotherapy Evidence Database) databases for articles published from 1st January 2009–31st December 2021. The following terms were used: 'intensive care unit' or 'critical care' and

'physical therapy' or 'physiotherapy' or 'physiotherapist' or 'mobilisation' or 'walking' or 'early ambulation' or 'therapeutic exercise' or 'rehabilitation'.

Types of study

All forms of study designs were eligible, including cohort observational studies (both prospective and retrospective), case control studies and opinion pieces. Additionally, service improvement projects and audits were included if available in full text.

Eligibility process

All titles identified were combined and duplicates removed. Titles and subsequently abstracts were reviewed by two of the research team, with any disagreements over inclusion discussed. Where consensus was not reached, a third researcher was utilised. Full text copies were obtained for the included articles, with those not freely available requested from the author through direct contact.

Data extraction and appraisal

Data extraction was performed using Joanna Briggs Institute (JBI) proformas relevant to each article (10). Extraction was completed by one member of the research team and checked for accuracy by another. Once data extraction was completed, only those deemed relevant to the objectives of the scoping review were critically appraised using the JBI methodology (9). Due to the widespread variation in research methodologies, participants and outcomes, a descriptive summary was completed.

Results

Searches performed

Initial searches identified 1331 articles published between January 2009–December 2021, reducing to 1099 after removal of duplicates. One systematic review was identified consisting of 85 primary papers, of which 43 were published prior to 2009 and a further 21 already included in the original searches. Therefore, a total of 1121 titles underwent review, of which 71 proceeded to abstract review and 28 full text papers were generated. Of these, six were excluded prior to critical appraisal (see Figure 1). Articles were most frequently excluded where they did not focus on either the role or recommended staffing for physiotherapists in critical care.

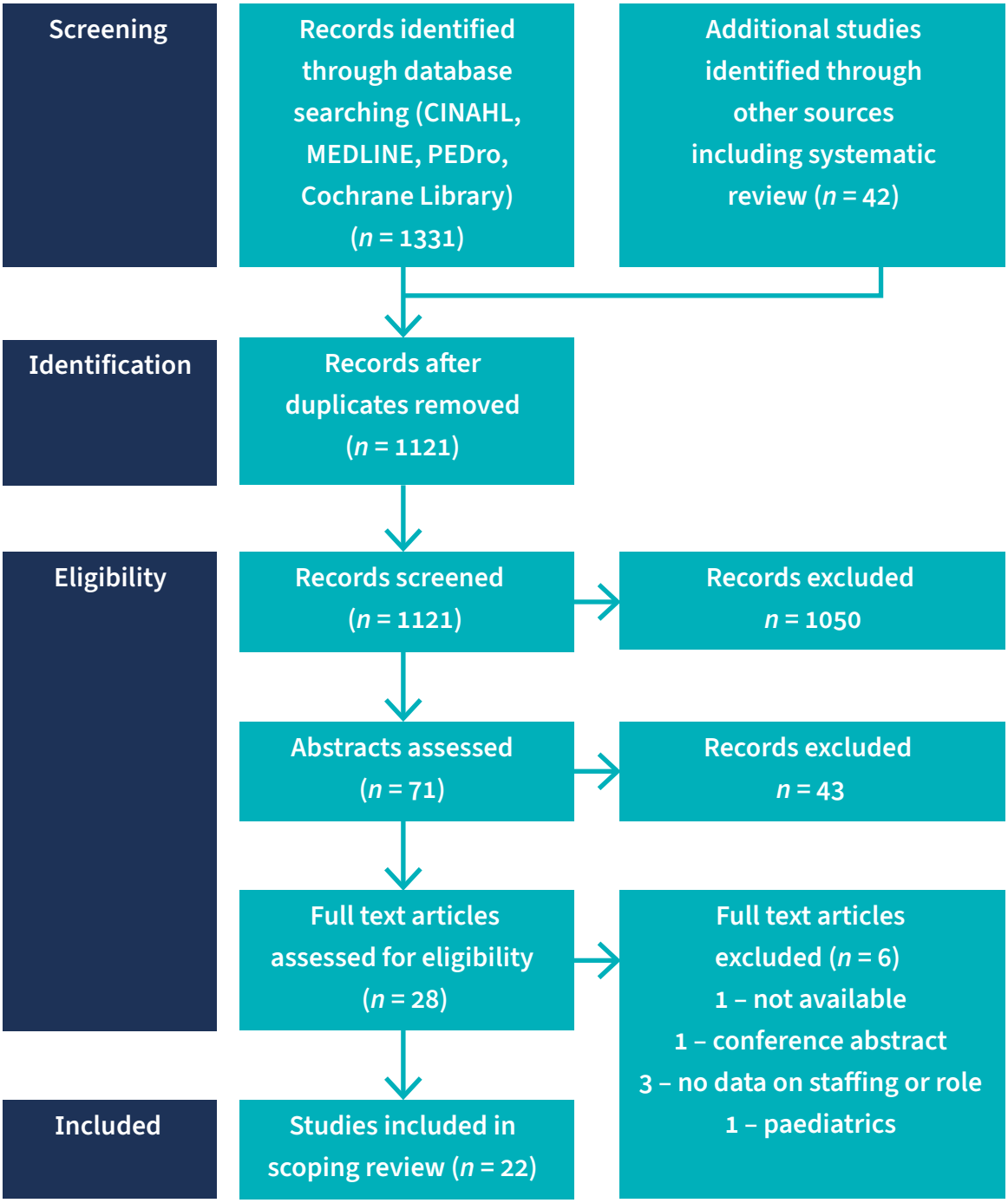

Figure 1: Search and eligibility flowchart.

Data extraction

A detailed overview of data extracted for both the role of physiotherapy in critical care and physiotherapy staffing is provided in Appendices 1 and 2.

Quality of research

The quality of all the studies were assessed using JBI proformas. No randomised control trials or control trials were included, with the majority ($n = 16$) being survey-based studies. All the included studies had a clear rationale for completion. However, while some had clear research aims and explanations of methods, they frequently reported very low response

rates (often <30%). The minimum standards studies in the U.K. (7) and Australia (6) recorded higher response rates (65% and 90% respectively) but this was achieved through targeted invitation and regular follow-up.

Surveys from two of the articles (11, 12) were completed by either nursing or medical staff members, with no input from physiotherapy staff and therefore generated a lack of clarity of roles and responsibilities. Additionally, three studies (13, 14) used scenario-based questions to review role and responsibilities, however the reviewers (Paul Twose, Vicky Newey and Una Jones) perceived that due to differences in practice across the world with regards to referral criteria and interventions, the results lacked generalisability to other nations or U.K. practice.

Of the non-survey-based studies, two utilised focus groups (8, 15), both of which had clear objectives and methodologies. Additionally, both utilised an appropriately sized and selected sample to ensure congruity between the research question and the results reported. Neither study reflected on the role of the researcher within the method and data analysis however, this was not felt to influence the rigour of the studies.

Sommers et al (16) utilised available evidence in making guidelines for 3 consensus topics for physiotherapy in critical care. There was a clear link between the recommendations made and the available evidence including a detailed approach to systematic review.

Of the remaining studies, 2 followed appropriate methodologies for the completion of a service evaluation (17) and quality improvement project (18). Both had appropriately detailed interventions and clarity regarding the use of routinely collected data. Additionally, the methodologies provide sufficient clarity to allow the studies to be reproduced in other health care settings. Conversely, the discussion by Pawlik (19) lacked some clarity on its purpose and its approach to gathering relevant evidence, and hence appears based on the author opinion and experience.

Summary of findings

Population and country of study

Participants included physical therapists, physiotherapists, and critical care directors (medical staff) with experience ranging from three months to greater than 20 years. By country, most of the publications originated from South Africa (n = 5, 21.7%) (8, 15, 20, 21, 22) or U.S.A. (n = 4, 17.4%) (13, 18, 19, 23).

Study methodology

The 22 included studies were predominantly survey based (n = 16,72.7%) with only two U.K. based studies (17, 19). Studies utilised a variety of distribution options, including circulation via membership groups (7, 13, 23, 24), direct contact in local hospitals and health establishments (6, 8, 12, 14, 15, 16, 20, 22, 25, 26, 27, 28, 29) or via senior medical clinicians (11, 19, 30).

The non-survey based studies were a mixture of focus group studies (*n* = 2) (8, 15), consensus guidelines (*n* = 1), a discussion paper (*n* = 1) (19), service evaluation (*n* = 1) (17), and quality improvement (*n* = 1) (18). Of these papers, none were U.K.-based.

Study findings

A detailed summary of the study findings can be found in Table 1.

Role of physiotherapy in critical care

The predominant themes from the studies were the role of physiotherapist in the provision of respiratory based interventions. These include management of a range of presentations including atelectasis, pneumonia and acute respiratory distress syndrome (25), and specific respiratory focused physiotherapy interventions, for example, airway clearance techniques and manual hyperventilation (12, 20, 26). Studies also discussed the role (or lack thereof) of physiotherapists in the adjustment of ventilator settings, weaning decisions and readiness for extubation (17, 22, 24). The studies focusing on the minimum standards of clinical practice identified broader roles for physiotherapists including the delivery of rehabilitation and the importance of physiotherapists working as part of the multi-disciplinary team (6, 7, 8, 15). Only Summers et al (30) focused purely on early mobilisation and based on a consensus process, developed protocols for treating patients in critical care.

Physiotherapy staffing in critical care

The studies reviewing physiotherapy staffing levels had significant variations in findings. Physiotherapy to patient ratios were reported between one physiotherapist to four patients (26), increasing to 1:50 (12). This variation occurred across counties but also within nations particularly between urban and rural settings, and different hospital settings for example, private versus public (22). There was also variation in the presence of physiotherapists within critical care with authors reporting only 11–40% of critical care units having physiotherapy presence daily (29). None of the studies attempted to suggest appropriate physiotherapy staffing but more reported on existing levels. Additionally, none of the studies discussed U.K.-based physiotherapy staffing levels.

Discussion

This scoping review, to the authors' knowledge, is the first of its kind to review the evidence base for both the role and staffing levels for physiotherapy in critical care. However, based on the articles identified, it is not possible to form clear recommendations. The methodological quality and nature of studies reviewed mean that findings are not generalisable to physiotherapy practice across countries. The studies found were geographically dispersed across Africa, Europe, U.S.A., and Asia, further limiting generalisability to the U.K. This is particularly pertinent given the known variability in physiotherapy job titles and roles for example, physiotherapist, respiratory therapist, and physical therapist.

Role of physiotherapy in critical care

The role of physiotherapy in critical care is not clearly defined based on the evidence available in this scoping review. There is evidence that physiotherapists are involved in both respiratory management for example, airway clearance, positioning and delivery of on-call services, and a role within rehabilitation within the critical care. However, as most of the included studies had different aims and objectives, it is difficult to generalise the findings and hence define the role. Three studies reported on the minimum standards of practice for physiotherapists in critical care (6, 7, 8). Whilst these papers identified clear skills and knowledge required to work in critical care; these focus on the minimum level required by individuals rather than the overall responsibilities of a physiotherapy service. Furthermore, they are yet to be evaluated to determine the impact of defining these minimum standards on clinical practice or training programmes.

However, this scoping review has highlighted the presence of physiotherapists within critical care units internationally. Whilst the roles may differ from country to country, some fundamentals remain for example, combining both respiratory interventions and rehabilitation. There also appears to be greater similarity in the role of physiotherapy in particular countries, namely the U.K. (7), Australia (6), and South Africa (8, 20).

Physiotherapy staffing in critical care

Based on this scoping exercise, there is widespread variability in physiotherapy staffing within critical care, and the international nature of the studies included make recommendations challenging.

GPICS v2 (1) suggests a physiotherapist to patient ratio of 1:4 within U.K. critical care units, however it is relatively unknown if units are compliant with this suggestion. In 2016 the Critical Care Network National Nurse Leads (CC3N) (4) identified that many critical care units had limited access to AHPs although specific physiotherapy to patient ratios were not recorded (31).

Within this scoping exercise, international staffing ratios were reported in four studies, ranging from one physiotherapist to four beds (1:4) in Jordan (26) to 1:50 in Greece (12); with a theme of increased physiotherapists in the larger cities with teaching/academic hospitals compared to more rural areas (22). Barriers to perceived low staffing numbers included funding, lack of formal training, lack of role understanding and prioritisation of the service need (12, 26). Service provision varied as to whether physiotherapists were present on the unit only on weekdays or had an on-call service. Turkman et al (29) reported the complete absence of physiotherapy on-call services in Turkey versus 90% of respondents in Sri Lanka reporting the presence of an on-call service, of which 28% had overnight residence (25).

There was also variable reporting of static staff who were solely critical care based or those whose remit covered other clinical areas (24). Formal training and specific post qualification critical care training was difficult to clearly define with one study reporting a clear need for further formal training in respiratory physiotherapy (11).

Of the studies included, none were U.K.-based and therefore no assumptions can be made for the current U.K. physiotherapy workforce within critical care. As such it is not possible to generate any theories for appropriate workforce models beyond the recommendations of GPICS.

Limitations of scoping review

This scoping review utilised transparent methods throughout the entire process, ensuring a broad search of the literature. Eligibility of studies was ensured through a step-based approach to review, with all titles and abstracts being independently assessed by two researchers. Additionally, data extraction and appraisals adhered to JBI recommendations, with additional reviews completed by each researcher. The review was limited to 2009 onwards to reflect the timing of the publication of the guidelines for rehabilitation after critical illness and a likely shift in physiotherapy interventions towards delivery of rehabilitation.

As with all scoping reviews, there is the potential that not all available literature will have been captured, as well as some papers not being available to the research team at point of data extraction and appraisal. Specific papers known to the researchers, but not identified in the literature searches, were included at title eligibility phase. There are possible reasons for papers not being identified in the searches including specific journals not being included within databases or may reflect the search terms initially identified for use not capturing all aspects of physiotherapy practice within critical care. No new literature was included after this point.

Further research

Future research is needed to explore the role of physiotherapists working within critical care in the U.K. and to define the required physiotherapy staffing levels, as well as determine the impact of physiotherapy within the critical care environment. This will support future guidelines and service planning to ensure a value-based approach to physiotherapy provision and a focus on improving patient outcomes.

Conclusion

Based on this scoping exercise, there is currently a limited evidence base to support both physiotherapy staffing recommendations and role definition. Existing literature is often methodologically flawed in terms of responder bias and insufficient response rates. Furthermore, most of the available literature is based in healthcare systems outside of the

U.K. However, throughout the literature there is clear evidence of physiotherapy involvement within critical care services, including the provision of on-call services. Furthermore, this scoping review has highlighted the increasing focus on delivering evidence-based practice and recognises the need for further research to provide greater role definition and to explore the impact of physiotherapy involvement.

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Conflict of interest

None of the authors have any declarations of conflict of interest.

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Appendix 1: Data extraction for role of physiotherapy in critical care.

Author, country	Aims	Method-ology	Participants/outcomes	Results
Baidya et al, 2016 (14), Nepal	To identify the availability of physiotherapy services in ICU and articulate the common practices by physiotherapists in ICUs of Nepal.	Survey	52 physiotherapists from range of hospital types (government, semi-government and private hospitals). Survey consisted of a series of six scenarios of mechanically ventilated patients commonly encountered in the ICU. Questions related to likelihood of review, number of days a week, frequency of treatment, and treatment types.	Physiotherapy services to patients in ICU were provided after physician consultation in 68% of cases. Few hospitals had established criteria (13%). Likelihood of routine physiotherapy input varied with each clinical scenario – stroke most likely to receive physiotherapy whereas myocardial infarction was least likely. Most preferred physiotherapy treatment was chest physiotherapy (53.8%), with limited use of exercise therapy. Limited weekend physiotherapy input was recorded.
Cakmak et al, 2019 (25), Turkey	To: • Identify the charac-teristics of physiotherapy practice. • Determine barriers to-ward applying physiotherapy in ICUs in Turkey.	Survey	65 physiotherapists completed a 54-item survey determining the characteristics of physiotherapists and physiotherapy applications within ICU.	Main reasons for referral to physiotherapy were atelectasis (81.5%), pneumonia/lung infection (80%), acute respiratory failure (73.5%), post-operative cardiovascular surgery (62.5%), and chronic obstructive pulmonary disease-acute exacerbation (60%). Positioning (90.8%), active range of motion exercises (90.8%), breathing exercises (89.2%), passive range of motion exercises (87.7%), percussion (87.7%), mobilization (86.2%), vibration (86.2%), and postural drainage (86.2%) were the most used physiotherapy applications in the ICU.

Author, country	Aims	Method-ology	Participants/outcomes	Results
Cork et al, 2019 (17), U.K.	To determine whether, following an assessment of extubation suitability, physiotherapists could correctly predict the extubation outcome of intubated adults in the ICU.	Service evaluation	61 patients from single site ICU in London, U.K. Included all patients undergoing planned extubation who had a physiotherapy review. Primary outcome was extubation success.	Results for all physiotherapists demonstrated 40% sensitivity and 86% specificity, whereas specialised physiotherapists showed 100% sensitivity and 68 specificity.
Christakou et al, 2018 (24), Greece	To investigate the responsibilities and frequency of clinical procedures that physiotherapists perform within the intensive care unit in Greece, alongside the level of education and training of those physiotherapists.	Survey	140 respondents with a minimum of three months of working experience within a hospital ICU in Greece, recruited from Greek ICU Society's database. Survey consisted of 83 closed and open-ended short form questions. Collected data about hospital, involvement in care, clinical procedures, weaning procedures.	Most frequent respiratory care intervention was suctioning following respiratory care (62.9%). Limited involvement in adjustment of ventilator settings (84.3% never) or weaning (45.7% never). 40% never involved in evaluating method of functional ability, but 9.3% often involved in mobilising on ventilator.
Grammatopoulou et al, 2017 (12), Greece	To determine the scope of physiotherapy services provided in Greek ICUs in Athens.	Survey	103 physiotherapists working in ICUs in Athens completed a three-item survey based on the findings of the ESICM task force on physiotherapy for critically ill patients. 19 ICU directors also completed eight-item questionnaire related to the nature of the ICU and its functioning. What were the questions about?	100% of physiotherapists reported using airway clearance techniques and 33% involved in intubation procedures. 100% of physiotherapists provide active and passive exercise, and 65% involved in bed-to-chair transfers.
Hodgin et al, 2009 (13), U.S.A.	To determine the utilisation of inpatient physical therapy for patients recovering from critical illness.	Survey	482 physical therapy members of the APTA completed survey consisting of 6 different ICU patient scenarios that may require physical therapy input.	Physical therapy most likely to be routinely involved where primary pathology is either neurological or trauma. Therapeutic exercise and functional mobility retraining most likely to be utilised.

Author, country	Aims	Method-ology	Participants/outcomes	Results
Lottering et al, 2016 (20), South Africa	To conduct a nationwide survey to: • Determine the current practice of physiother-apists in SA ICUs. • Determine if physiothera-pists' practice in ICUs had changed since the previous report. • Validate the survey ques-tionnaire. In addition, SA physio-therapists' practice in ICU was compared with that reported in critical care and rehabilitation literature, to determine if current practice is evidence based.	Survey	108 participants completed the questionnaire. The questionnaire included demographics, ICU type, patient referral method, after-hours service provision, assessment and treatment techniques used in patient management, participation in inter-professional team meetings and professional development activities.	56% (n = 60) of respondents attended ward rounds in the ICU on a daily or weekly basis. Respondents were involved with the in-service training of colleagues, such as training junior physiotherapists to work safely in the ICU (n = 51, 47%). Treatment modalities performed 'very often' included manual chest clearance, mobilisation, and deep breathing exercises.

Author, country	Aims	Method-ology	Participants/outcomes	Results
Malone et al, 2015 (23), U.S.A.	National survey to determine the current status of physical therapists' practice in the ICU.	Survey	667 physical therapists from the acute care section of APTA, completed a two-part questionnaire. Section one of survey explored demographics of hospital/ICU; staffing patterns; training; self-confidence in working on ITU; consultation and treatment guidelines; barriers to providing rehabilitation. Section two of the questionnaire investigated perceptions of rehabilitation practice related to five scenarios.	For the case studies, physical therapy was less likely for patients with more complex medical conditions and the prescribed frequency was decreased as complexity increased.
Morar et al, 2016 (22), South Africa	To determine the extent of physiotherapists' involvement in weaning and extubation of patients from mechanical ventilation and whether current practice is evidence based.	Survey	425 respondents from intensive care units across SA. Questionnaire explored ventilator weaning and physiotherapy modalities used to support weaning.	Majority (approximately 80%) of respondents 'never' adjusted ventilator settings related to ventilator mode, respiratory rate, inspiratory pressure etc. 73% never or seldom involved in decision to start weaning and 61% not involved in extubation decisions. For physiotherapy modalities exercise, early mobilisation out of bed (77%), and deep breathing exercises (77%) were most utilised.

Author, country	Aims	Method-ology	Participants/outcomes	Results
Pawlik et al, 2013 (19), U.S.A.	To explore issues that physical therapy profession needs to address as the rehabilitation management of the patient with critical illness evolves.	Discussion	Discussion by physical therapist and medical doctor aimed to investigate the issues that the physical therapy profession need to address as the rehabilitation management of the patient with critical illness evolves.	Key themes identified as: • *Competence*: academic preparation of physical therapists and role of specialist versus junior staff members. • *Resources:* physical therapists should be integral members of the critical care team. • *Prioritisation:* treatment needs to be at optimal time to aid recovery and timely discharge. • *Outcome measures:* FIM to assess both physical and cognitive disability. Other outcome measures include PFIT and MRC. • Input across the continuum.
Plani et al, 2017 (15), South Africa	Explore the perceptions of physiotherapists on the minimum clinical standards that's physiotherapists working in ICU should adhere to for delivering safe and effective services to critically ill patients.	Focus groups	25 physiotherapists working within ICUs involved in three focus groups. Three domains were explored: 1 Knowledge. 2 Skill. 3 Attributes.	66 concepts (54% knowledge, 35% skills; 10% attributes). Consensus reached on only six concepts. Three overarching themes: 1 Integrated medical knowledge. 2 MDT teamwork. 3 Physiotherapy practice.

Author, country	Aims	Methodology	Participants/outcomes	Results
Sigera et al, 2016 (26), Sri Lanka	To determine: 1 The availability of critical care physical therapist services. 2 The equipment and techniques used and needed. 3 The training and continuous professional development of physical therapists.	Survey	213 physical therapists in Sri Lanka completed an interviewer-administered questionnaire. Questions focused on experience of staff, distribution of physical therapists, work patterns and availability of 24-hour physical therapy.	Physical therapy interventions included manual hyperinflation (84%), breathing exercises (67%) and manual airway clearance (59%). Incentive spirometry was present in 80% of critical care units but only utilised by 3% of physical therapists.
Skinner et al, 2016 (6), Australia & New Zealand	To establish a consensus based minimum clinical practice standards for physiotherapists working in critical care in Australia and New Zealand.	Survey	61 physiotherapists working in Australia and New Zealand took part in a Delphi study to establish consensus based minimum clinical practice standards. Consensus based on 70% agreement.	Consensus achieved on 132 items of physiotherapy practice, with 67 items considered not essential for physiotherapy practice. All remaining items failed to reach any consensus. Comments raised recognised that some items were specific to ICU specialities for example, burns or ECMO, and as such were not needed by all physiotherapists working within critical care.

Author, country	Aims	Method-ology	Participants/outcomes	Results
Summers et al, 2015 (31), Netherlands	To formulate an evidence based, expert driven, practical statement within the ICF domains, regarding diagnostics and effective and safe physiotherapy treatment strategies aiming at early mobilisation and physical activity for patients in an intensive care unit.	Guideline	Postal survey to 70 Dutch physiotherapists to identify 3 'clinical key questions', which were then explored via a systematic literature search and expert opinion from 2 intensivists and 16 physiotherapists.	3 key clinical questions on recommendations for mobilisation, clinimetrics for quantifying physical function and which physiotherapy interventions most effective. Physiotherapy modalities identified included passive exercise (level two), stretching (level two), passive cycling (level two), CPM (level two) and splinting (level four).
Twose et al, 2019 (7), U.K.	To standardise the knowledge and skills of physiotherapists working in critical care in U.K. – develop minimum standards to support training and reduce variability in clinical practice.	Survey	114 U.K. based physiotherapists (clinical and academic) took part in a Delphi study to establish consensus based minimum clinical practice standards. Consensus based on 70% agreement.	107 items considered essential to clinical practice in U.K. critical care units. Items categorised into: 1 Assessment. 2 Condition. 3 Treatment. 73 items considered not essential, and no consensus achieved for 33 items. Themes reported included specificity to type of critical care for example, burns, and to be included as part of multi-disciplinary approach.

Author, country	Aims	Method-ology	Participants/outcomes	Results
van Aswegen et al, 2017 (8), South Africa	To explore the perceptions of experienced physiotherapists as to the minimum clinical standards for physiotherapy in SA ICUs. To better understand the: 1 Knowledge base to be mobilised. 2 Skills and competencies to possess. 3 Attributes to be engaged by physiotherapists working in ICU to ensure safe and effective service delivery to critically ill patients.	Focus group	25 physiotherapists working in SA ICUs. Three categories explored: 1 Knowledge base to be mobilised. 2 Skills and competencies to possess. 3 Attributes to be engaged by physiotherapists working in ICU to ensure safe and effective service delivery to critically ill patients.	Three key themes identified: 1 Integrated medical knowledge including pathology, anatomy and physiology. ICU environment. 2 Multidisciplinary working including CPD, communication, team members and ethics. 3 Physiotherapy practice including handling skills, clinical reasoning, patient care and interventions.
van der Lee et al, 2019 (28), Australia	To determine expert consensus for respiratory physiotherapy management of intubated and mechanically ventilated adults with CAP, which could inform development of guidelines for clinical practice.	Survey	29 physiotherapists took part in a Delphi study to establish physiotherapy management of intubated and mechanically ventilated adults with CAP. Consensus based on 70% agreement.	The Delphi study resulted in 38 expert consensus statements covering the seven key domains. A high proportion on consensus items related to physiotherapy assessment based on a systems approach. A much lower proportion of items related to physiotherapy treatment, reflecting the variability in clinical practice.

Author, country	Aims	Method-ology	Participants/outcomes	Results
Yeole et al, 2015 (29), India	To evaluate qualifications of physiotherapists, hospital infrastructure available for physiotherapists, and the current physiotherapy practices in ICUs of hospitals across the state of Maharashtra, India.	Survey	73 physiotherapists across 50 hospitals completed questionnaire. Data captured on hospital type, physiotherapy demographics and the role of physiotherapists.	68% of respondents were working private hospitals. 63% reporting being available overnight (48% as a resident). Majority of respondents (80%) performed 'chest wall techniques', with 86% using positioning and 61% joint mobilisation. Only 44% of physiotherapists involved in patient and family education regarding the condition and prognosis of the patient's health.

APTA = American Physical Therapy Association; CAP = community acquired pneumonia; CPD = continuous professional development; CPM = continuous passive movement; ESICM = European Society of Intensive Care Medicine; FIM = functional independence measure; ICU = intensive care units; MDT = multi-disciplinary team; MRC = Medical Research Council; PFIT = physical function in intensive care test; SA = South Africa; U.K. = United Kingdom.

Appendix 2: Data extraction for physiotherapy staffing within critical care.

Author, country	Aims	Methodology	Participants/ outcomes	Results
Al-Nassan et al, 2018 (27), Jordan	To determine the current status of physical therapy practice in the ICUs in four different sectors of Jordanian hospitals.	Survey	Online survey completed by 50 physical therapists. Survey consisted of three sections with 23 items: • Section one addressed demographics and descriptions of physical therapy practice in ICUs (10 items). • Section two addressed the level of education and training for intensive care physical therapy (7 items). • Section three addressed the main barriers to practice (6 items).	Staffing of physical therapists working in ICUs relative to the total ICU beds was highest in public hospitals (1:4 versus overall 1:10). Among all participants only 4% had specialist post graduate ICU training. Barriers to ICU practice included prioritisation of service and adequate perceived importance.
Christakou et al, 2018 (24), Greece	To investigate the responsibilities and frequency of clinical procedures that physiotherapists perform within the intensive care unit in Greece, alongside the level of education and training of those physiotherapists.	Survey	140 respondents with a minimum of three months of working experience within a hospital ICU in Greece recruited from Greek ICU society's database. Survey consisted of 83 closed and open-ended short form questions. Collected data about hospital, involvement in care, clinical procedures, weaning procedures.	21% of physiotherapists were fulltime within critical care, with 40% of ICUs having one physiotherapist on ICU each day.

Grammatopoulou et al, 2017 (12), Greece	To determine the scope of physiotherapy services provided in Greek ICUs in Athens.	Survey	103 Physiotherapists working in ICUs in Athens completed a three-item survey based on the findings of the ESICM task force on physiotherapy for critically ill patients. 19 ICU directors also completed eight-item questionnaire related to the nature of the ICU, number and availability of physiotherapists, and adequacy of the physiotherapy service.	Results showed a 1:50 to 1:12 range of physiotherapists to ICU beds. Majority of staff were rotational (78.9%) with physiotherapist services provided in all ICUs in the morning and less frequently during the afternoon (52.6%). 89.5% of ICU directors reported the number of physiotherapy shifts in ICU were inadequate.
Johnson et al, 2019 (18), U.S.A.	The primary aim of this study was to investigate if changes in PT delivery and patient outcomes occurred for patients with prolonged cardiovascular critical illness as a result of increased physical therapy staff dedicated to ICU.	Quality improvement	During six-month quality improvement initiative ICU physical therapy staff increased from two to 4. 114 cardiovascular patients (52 in the baseline period and 62 in the QI period) met the criteria for prolonged critical illness.	Daily PT treatment duration increased (significantly or non-significantly?) for each patient from 51.7 (±12.9) minutes in the baseline period to 59.4 (±25.5) minutes in the QI period. There were non-significant differences observed in physical function change between the baseline and QI period, for both the ICU and overall hospital stay. The median (IQR) post-ICU LOS in the baseline period was 5.0 (0.0, 7.7) (is this range or CI?) days compared to 2.0 (0.0, 6.5) days in the QI period.

Lottering et al, 2016 (20), South Africa	To conduct a nationwide survey to: 1 Determine the current practice of physiotherapists in SA ICUs. 2 Determine if physiotherapists' practice in ICUs had changed since the previous report. 3 Validate the survey questionnaire. In addition, SA physiotherapists' practice in ICU was compared with that reported in critical care and rehabilitation literature, to determine if current practice is evidence based.	Survey	108 participants completed the questionnaire. The questionnaire included demographics, ICU type, patient referral method, after-hours service provision, assessment and treatment techniques used in patient management, participation in inter-professional team meetings and professional development activities.	Respondents indicated that patients in ICU were referred for physiotherapy by doctors or nurses (number of respondents = 59, 54%). An after-hours physiotherapy service was provided by 72% (*n* = 78) of respondents to ICUs during weekdays. Most respondents (*n* = 105, 97%) provided weekend physiotherapy services to their ICUs.
Li et al, 2012 (11), China	To explore current ICU respiratory care resources and practices, requirements for respiratory therapists, and the barriers to recruit respiratory therapists.	Survey	194 respondents from ICUs in Beijing, China: 134 physicians, 60 nurses. Survey explored existing staffing, respiratory interventions, and perceived requirement for respiratory therapists.	18 respiratory therapists working across 7 ICUs (6 hospitals) with ratio of 1:36 patients. 86.1% of respondents suggested that respiratory care services should be provided by respiratory therapists. The main barrier for recruitment was access to formal training.

Malone et al, 2015 (23), U.S.A.	National survey to determine the status of physical therapists' practice in the ICU.	Survey	667 physical therapists from the acute care section (ACS) of APTA. Section one of survey explored demographics of hospital/ICU; staffing patterns; training; self-confidence in working on ITU; consultation and treatment guidelines; barriers to providing rehabilitation. Section two investigated perceptions of rehabilitation practice related to five scenarios.	Staffing (number of PTs per 100 beds) -2.4 (1.7–3.3) for hospital beds and 6.3 (4–10) for the ICU, with academic hospitals reporting lower ICU staffing than community hospitals. 31% of respondents had formal training in ICU. Common barriers to physical therapy were insufficient staffing (44%), lower prioritisation (36%) and lack of consultation criteria (35%). 38.6% reported faculty-based guidelines for ICU consultations.
Sigera et al, 2016 (26), Sri Lanka	To determine: 1 The availability of critical care physical therapist services. 2 The equipment and techniques used and needed. 3 The training and continuous professional development of physical therapists.	Survey	213 physical therapists in Sri Lanka completed an interviewer-administered questionnaire. Questions focused on experience of staff, distribution of physical therapists, work patterns and availability of 24-hour physical therapy.	54% of respondents had >5 years' experience of which most, 56%, worked within specialised critical care units. 90% of critical care units had a PT oncall system including 28% resident overnight.

Turkmen et al, 2014 (30), Turkey	To investigate to what extent ICUs in university and private hospitals in Turkey meet the minimum requirements for equipment and workforce set out by national standards.	Survey	Survey questionnaire together with a permit letter was mailed to the Chief of Medicine and the Head of the Nursing Department at each of the identified hospitals 145 questionnaires returned. Questions were devoted to medical devices and equipment, and workforce.	11.7% respondents reported the presence of a physiotherapist within intensive care unit. Where present, most worked within neurosurgical ICUs. No physiotherapists worked oncall/out of hours. 2008 standards for Turkish ICUs did not state requirement for physiotherapist within intensive care unit.
Yeole et al, 2015 (29), India	To evaluate qualifications of physiotherapists, hospital infrastructure available for physiotherapists, and the current physiotherapy practices in ICUs of hospitals across the state of Maharashtra, India.	Survey	73 physiotherapists across 50 hospitals completed questionnaire. Data captured on hospital type, physiotherapy demographics and the role of physiotherapists.	68% of respondents were working private hospitals. 63% reporting being available overnight (48% as a resident).

APTA = American Physical Therapy Association; ESICM = European Society of Intensive Care Medicine; ICU = intensive care units; PT = physical therapist; SA = South Africa.

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Airway clearance techniques for the intubated adult: a scoping review

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Keywords | Intensive care unit, physiotherapy, sputum clearance, retained secretions, mechanical ventilation.

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Abstract

Objective

The aim of this scoping review was to understand the extent and type of evidence available in relation to airway clearance techniques in the intubated adult.

Introduction

This review was commissioned by the Association of Chartered Physiotherapists in Respiratory Care (ACPRC) special interest group as a method of summarising the available evidence on this topic on behalf of its members. Airway clearance in the intubated adult is a key objective of respiratory physiotherapists and although evidence-based guidelines exist in this area, there is no recent summary regarding the extent of the literature which could inform future research and clinical practice.

Inclusion criteria

Studies which investigated adults who were intubated either via an endo-tracheal or tracheostomy tube met the criteria. All study designs, including reviews, case reports and animal studies, which reported any physiotherapy-related airway clearance techniques were included.

Methods

The following databases were searched: SCOPUS, PubMed, PEDro, CINAHL Plus, and Clinical Trials Registry. The search was completed in December 2021 and limited to full text papers published since 2011. Following the key word search strategy, each title and abstract was screened for relevance to the scoping review aim and the study design was identified. *Population*, *intervention*, *comparator* and *outcome* (PICO) data extraction was completed for all included papers in order to identify themes. The number and type of evidence retrieved, as well as key themes and outcomes were summarised.

Results

The scoping review identified 138 suitable papers for inclusion. Of these, 11 were systematic reviews and 39 were randomised clinical trials, representing a moderately large evidence-base on this topic. Also included were other experimental, observational and qualitative studies, narrative reviews and animal and bench studies. Key interventions were identified including multi-modal chest physiotherapy, hyperinflation and manual chest compression techniques. Reported outcome measures were mainly short-term, such as sputum yield and oxygenation, whilst longer-term outcome measures such as ICU length of stay and ventilator-associated pneumonia (VAP) rates were reported less frequently. Outcome measures related to physiological stability were also reported by some studies.

Findings of the review were that airway clearance techniques for the intubated adult appear to be safe. There is a moderate body of evidence regarding their efficacy for short-term outcomes such as sputum yield, oxygenation and respiratory mechanics. There is limited evidence regarding their efficacy for longer-term outcomes.

Conclusion

This scoping review summarises the extent of available evidence regarding airway clearance for intubated adults. Future research should focus on the effects of airway clearance techniques on longer-term outcome measures such as VAP rates and extubation outcome.

Introduction

The ACPRC editorial board is comprised of respiratory physiotherapy clinicians and academics who have volunteered through their ACPRC membership to be part of the editorial board. The purpose of the board is to lead scoping, commissioning, co-ordination and delivery of all new ACPRC guidance documents and resources, in order to facilitate knowledge sharing and drive improvements in the quality of care for respiratory patients.

The editorial board discussed potential areas for investigation which had been suggested by its membership and agreed that the area of airway clearance for the intubated adult should be prioritised. The lead author Gabriella Cork, as a member of the editorial board, was nominated to lead the scoping review and other ACPRC members who were practising respiratory physiotherapist clinicians volunteered to assist with the process.

Airway clearance for the intubated adult is an important responsibility for respiratory physiotherapists in the intensive care unit (ICU) (1) and involves the mobilisation and subsequent removal of respiratory secretions via the endotracheal or tracheostomy tube. Intubation and the associated mechanical ventilation, prolonged recumbency and sedation result in reduced cough efficacy, reduced mucociliary transport and atelectasis which can in turn lead to retained secretions and ventilator-associated pneumonia (2, 3, 4, 5). Physiotherapeutic techniques to assist with the removal of sputum from the intubated patient such as manual chest compression, hyperinflation and positioning are frequently used by physiotherapists (6, 7). However, evidence investigating the efficacy of such techniques has been deemed overall of poor quality with conflicting findings (8).

Recent Faculty of Intensive Care Medicine (FICM) guidelines recommend 'targeted airway clearance interventions' for invasively ventilated patients but do not stipulate which airway clearance interventions should be utilised (9). Furthermore, the same publication recommends that individual physiotherapy services should develop their own evidence-based guidelines for the use of airway clearance techniques. A major purpose of this scoping review was to determine whether there is sufficient evidence available on this topic to inform collaborative clinical guidelines.

A preliminary search of SCOPUS and the Cochrane Database of Systematic Reviews was conducted and whilst recent reviews in this area exist, they have focused on individual techniques such as manual therapy (10) or hyperinflation (11, 12), on specific populations such as those with community-acquired pneumonia (13) and traumatic brain injury (14), or on specific outcomes such as ventilation-associated pneumonia (VAP) rates (15). One systematic review (8) did have a wider focus and included a variety of physiotherapeutic techniques and outcomes relevant to airway clearance, however a number of new experimental studies have subsequently been published. These have not yet been captured by guidelines, recommendations or systematic review and may further contribute to the knowledge base in this topic.

The aim of this scoping review is to understand the extent and type of evidence in relation to airway clearance in the intubated adult in order to inform future recommendations for respiratory physiotherapy clinicians and researchers.

Review question

What is the extent of the current evidence-base in relation to airway clearance in the intubated adult?

Eligibility criteria

Participants

Adults who were intubated either via endotracheal or tracheostomy tube at the time of the investigation. Paediatric studies were excluded.

Concept

Airway clearance techniques that are performed by physiotherapists as summarised by Berry et al (16). Additional airway clearance techniques that are more commonly performed by medical staff such as bronchoscopy or that are pharmacological in nature were excluded. Techniques such as automated lateral bed rotation, humidification or endotracheal suctioning alone were excluded as these were deemed to be primarily routine, nurse-delivered interventions.

Context

Airway clearance techniques for the intubated adult are usually performed in the ICU, however studies were not excluded if they investigated intubated adults in other clinical settings such as weaning units or post-op recovery areas. This scoping review was planned and initial searches conducted prior to the global COVID-19 pandemic, therefore studies relating to the treatment of COVID-19 were excluded as they were deemed by the co-authors to be beyond the initial remit and purpose of the review.

Types of sources

This scoping review considered both experimental and quasi-experimental study designs including randomised controlled clinical trials, non-randomised controlled trials and before and after studies. In addition, analytical observational studies including prospective and retrospective cohort studies, case-control studies and analytical cross-sectional studies were considered for inclusion. This review also included descriptive observational study designs including case series, individual case reports and descriptive cross-sectional studies as well as animal and bench studies. Qualitative studies on this topic were additionally summarised alongside systematic reviews and meta-analyses that met the inclusion criteria.

Opinion papers (including editorials) as well as conference abstracts were excluded.

Methods

The scoping review was conducted in accordance with the JBI methodology for scoping reviews (17).

Search strategy

An initial limited search of SCOPUS was undertaken to identify articles on the topic. The text words contained in the titles and abstracts of relevant articles, the index terms used to describe the articles, and a collaborative, iterative process by the co-authors were used to develop a full search strategy (see Appendix 1 for full SCOPUS search strategy). The search strategy, including all identified keywords and index terms, was adapted for each of the included databases. The reference lists of all review papers were subsequently screened for additional studies.

Studies published in any language where a full English version was available were included. Studies published from 2011 onwards were included as the most comprehensive systematic review was published in 2013, and the vast majority of its 85 included papers were published pre-2011 (8).

The databases searched were SCOPUS, PubMed, CINAHL Plus, and PEDro. Google Scholar search engine was additionally employed using the same search terms, limited to the initial 500 papers due to default sort by relevance. The Clinical Trials Registry was also searched for unpublished studies that were completed within the previous three years which might reasonably be in the process of being published at the time of the review. The final search was completed in December 2021.

Source of evidence selection

Following the search, titles and abstracts were screened by co-authors (Clare Wade, Alison Gordon, Anna Vaughan-France, Amelia Palmer, Katy Walker and Una Jones) for assessment against the inclusion criteria. Potentially relevant sources were retrieved in full and uploaded into EndNote X9, 2018 (Clarivate Analytics, P.A., U.S.A.) and duplicates removed. The full text of selected citations was assessed in detail against the inclusion criteria by the lead author (Gabriella Cork) and cross-checked independently by Clare Wade. Reasons for the exclusion of evidence following full text review were recorded and reported (Figure 1).

Data extraction and synthesis

Data regarding study design, population, intervention, comparator and outcome (PICO) was extracted from papers included in the scoping review by the co-authors using a data extraction tool developed by Una Jones. The data extracted included key findings relevant to the review question. Themes were identified during the data extraction process and the papers grouped both by type of evidence and sub-themes within the overall airway clearance topic. For papers which included more than one type of airway clearance, the intervention was classified as 'multi-modal chest physiotherapy'. Key outcome measures were also identified. Due to the breadth of the scoping review, quality assessment of the experimental papers was not undertaken beyond classifying them according to their study design.

Results

The scoping review retrieved 138 relevant papers (see Figure 1). Of these, 11 were systematic reviews (summarised in Appendix 1) and 39 were randomised clinical trials (summarised in Appendix 2), see Figure 2 for full break-down of papers by evidence-type and Appendices 3–8 for summaries of all other included papers.

The most common reported intervention was multi-modal chest physiotherapy with 45 publications exploring this topic. Common airway clearance techniques such as hyperinflation and manual chest compressions were also extensively studied. Figure 3 gives a full break-down of the papers included in the scoping review according to their theme.

The key interventions, outcome measures and findings from comparative studies included in this scoping review are summarised in Table 1. The most commonly reported outcome measures were sputum yield and oxygenation.

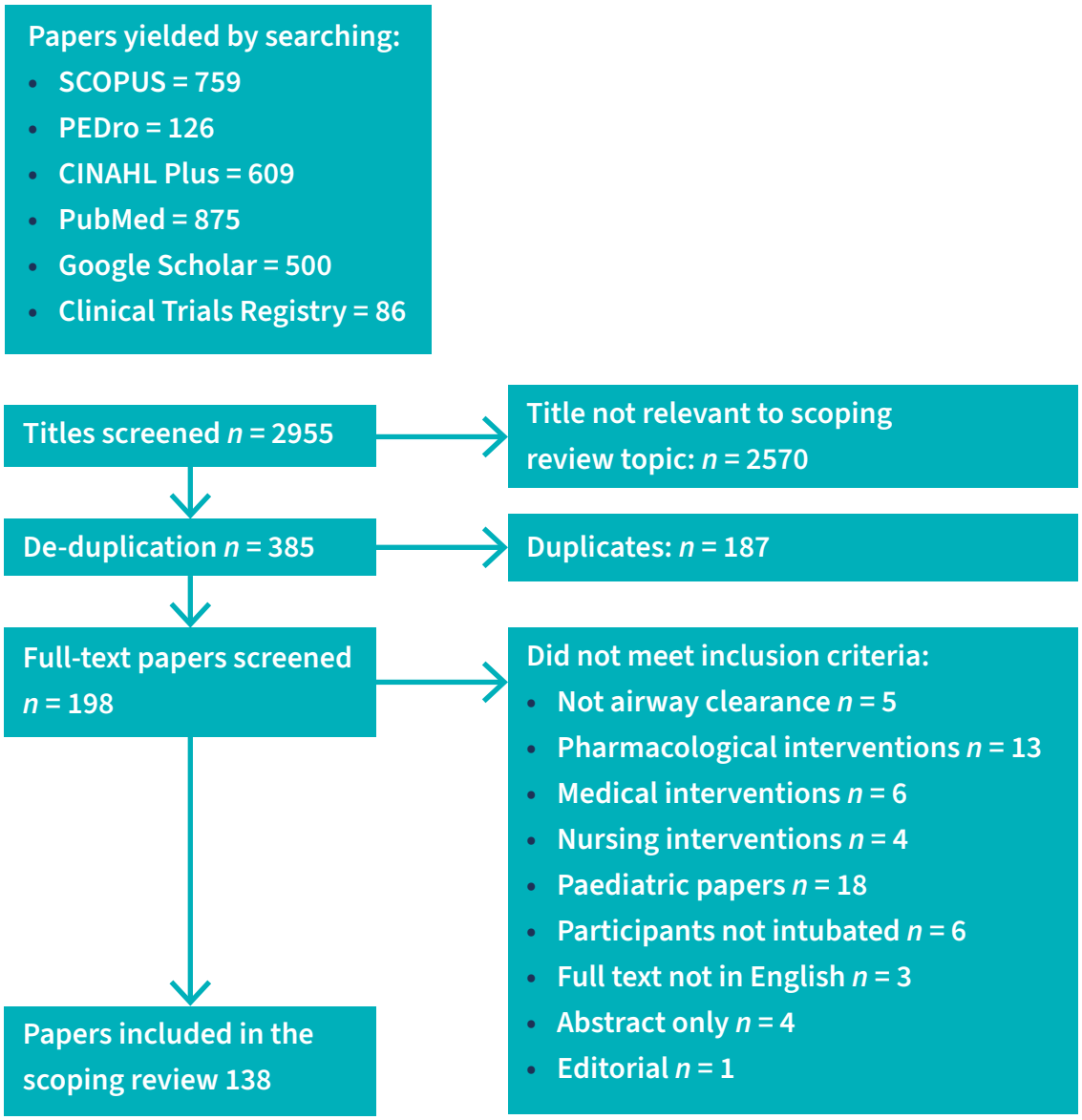

Figure 1: PRISMA flow chart for the scoping review process.

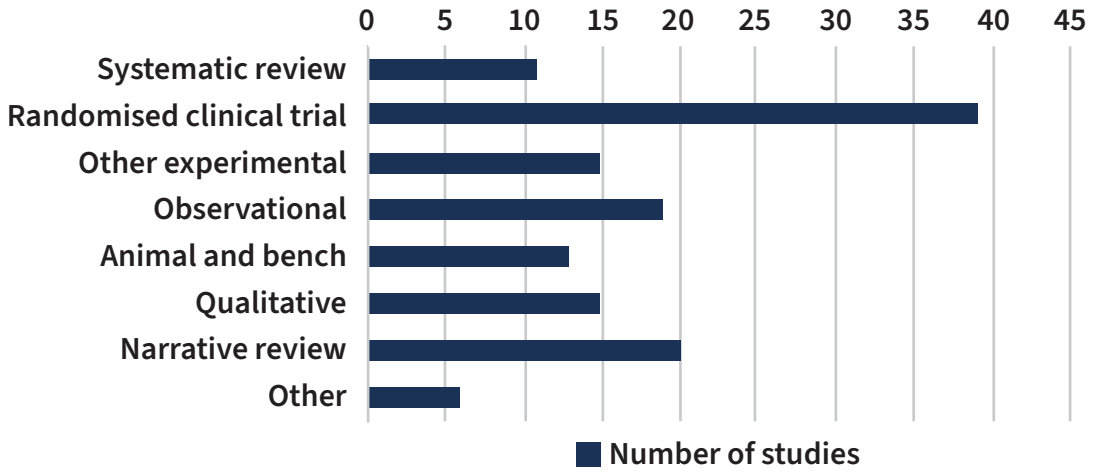

Figure 2: Summary of included sources according to evidence type.

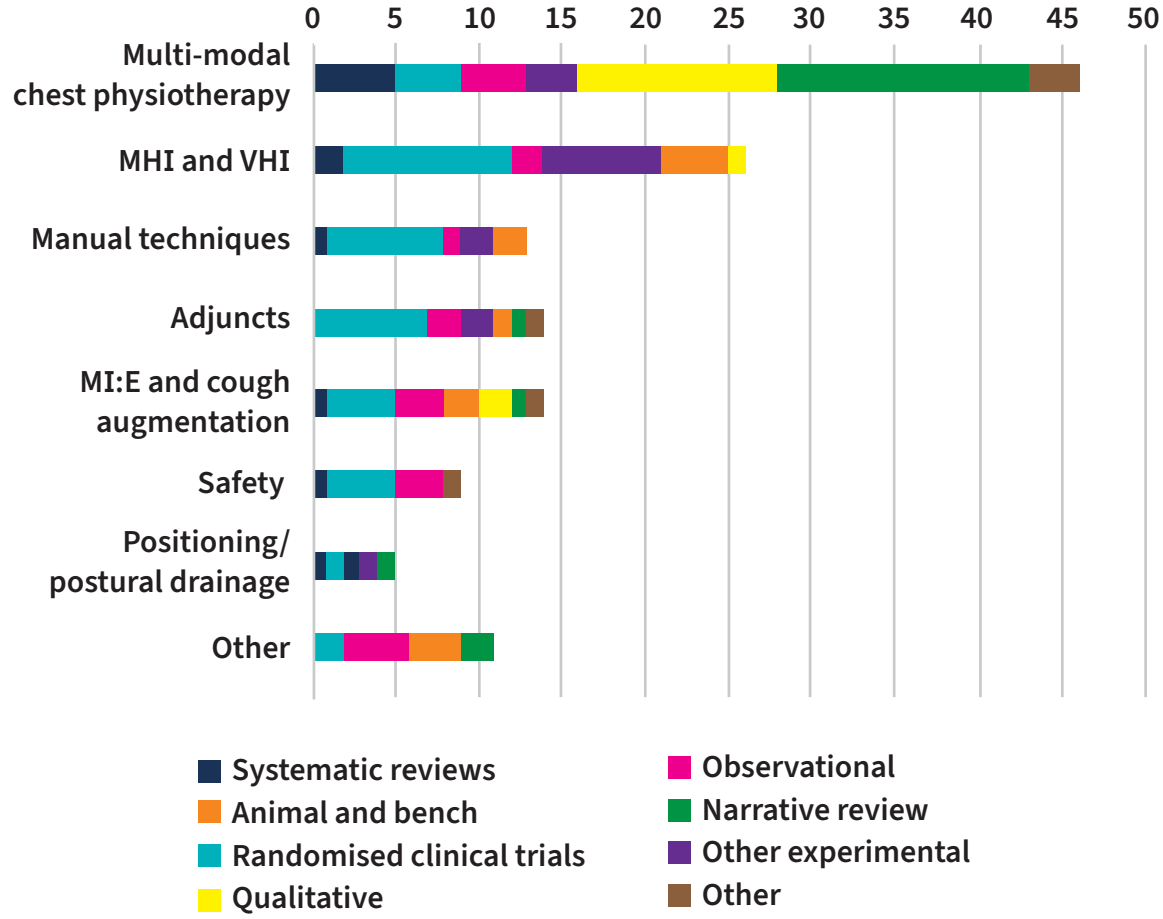

Figure 3: Summary of included sources according to theme and evidence type.

MHI = manual hyperinflation; VHI = ventilator hyperinflation; MI:E = mechanical in-exsufflation.

Table 1: Summary of key interventions and outcome measures.

		Multi-modal	MHI/VHI	Manual techniques	Cough augmentation	Positioning	Adjuncts
Short-term outcome measures	Sputum yield	*Systematic review:* van der Lee, 2020+ *RCT:* Naue, 2014+	*Systematic review:* Anderson, 2015= Paulus, 2012+ *RCT:* Dennis, 2012= Jacob, 2020+ Naue, 2011= Naue, 2019+ *Experimental:* Bhoir, 2017= El-Deen, 2013+ Ibrahim, 2018+	*Systematic review:* Borges, 2017= *RCT:* Genc, 2011= Guimaraes, 2014+ Yousefnia-Darzi, 2016+ *Laboratory:* Ouchi, 2020+ *Experimental:* Suh, 2011=	*RCT:* Coutinho, 2018= de Camilis, 2018+ Martinez-Alejos, 2021+	*RCT:* Shetty, 2020+	*RCT:* Chicayban, 2011+ Jones, 2013+ Kluayhom-thong, 2019+ *Experimental:* Kuyrukluyildiz, 2016+
	Oxygenation	*Systematic review:* Andrews, 2013+ *RCT:* Mohamed, 2017+ *Observational:* Meawad, 2018 Moreira, 2015= Ntoumenopoulos, 2014- *Experimental:* Hariedy, 2015+	*Systematic review:* Anderson, 2015= Paulus, 2012+ *RCT:* Malekzadeh, 2016+ Mohamed, 2017+ *Observational:* Frank, 2015+ *Experimental:* Bhoir, 2017= El-Deen, 2013+ Ibrahim, 2018+ Raafat, 2011+ Waqas, 2014+	*Systematic review:* Borges, 2017= *RCT:* Genc, 2011= Kohan, 2014+ *Observational:* Via, 2012+ *Experimental:* Ashtankar, 2019+	None	*Systematic review:* Hewitt, 2016+ *Experimental:* Guner, 2015=	*Observational:* Lee, 2011= *Experimental:* Kuyrukluyildiz, 2016+
	Respiratory mechanics	*Systematic review:* Andrews, 2013+ Stiller, 2013+ Van der Lee, 2020+ *RCT:* Naue, 2014+ Observational: Moreira, 2015+	*Systematic review:* Anderson, 2015= Paulus, 2012+ *RCT:* Linnane, 2019= Paulus, 2011+ Ribeiro, 2019 *Experimental:* Bhoir, 2017=	*Systematic review:* Borges, 2017= *Observational:* Via, 2012+ *Experimental:* Ashtankar, 2019+ Suh, 2011+	*RCT:* de Camilis, 2018+ Martinez-Alejos, 2021+	None	*RCT:* Chicayban, 2011+ Chuang, 2017+ *Experimental:* Longhini, 2020+
	Peak expiratory flow/expiratory flow bias	None	*RCT:* Ribeiro, 2019 *Laboratory:* Bennett, 2015 Chapman, 2019 Li Bassi, 2019= Thomas, 2015 *Experimental:* Paulus, 2014	*RCT:* Amaral, 2019+ Oliveira, 2019+ *Laboratory:* Marti, 2013+	*Laboratory:* Guerin, 2011 Volpe, 2018	*Laboratory:* Li Bassi, 2014+	*RCT:* Chicayban, 2011+ *Laboratory:* Fernandez-Restrepo, 2017

Longer-term outcome measures	Ventilator-acquired pneumonia rates	*Systematic review:* Pouzuelo-Carrascosa, 2018= Stiller, 2013= Wang, 2019= *RCT:* Mohamed, 2017+ Pattanshetty, 2011+ *Observational:* Kubo, 2021+	None	*RCT:* El-Hamid, 2017+	*Observational:* Kuroiwa, 2021+	*Laboratory:* Li Bassi, 2014+	*RCT:* Spapen, 2015+ *Experimental:* Kuyrukluyildiz, 2016+
	Mortality	*Systematic review:* Pouzuelo-Carrascosa, 2018+	None	None	None	None	None
	ICU length of stay/ duration of mechanical ventilation	*Systematic review:* Pouzuelo-Carrascosa, 2018= Stiller, 2013= Van der Lee, 2020= *RCT:* Berti, 2012+ Pattanshetty, 2011- Mohamed, 2017+ *Experimental:* Castro, 2013+ Wang, 2018=	None	None	*Systematic review:* Rose, 2017+	None	*RCT:* Chen, 2016+ Clinkscale, 2012= *Observational:* Lee, 2011=
	Extubation/ weaning success	*Experimental:* Wang, 2018+	None	None	*Systematic review:* Rose, 2017+ *RCT:* Goncalves, 2012+ *Observational:* Bach, 2015	None	None
Physio-logical stability	Haemodynamic observations	*RCT:* Blattner, 2017- *Observational:* Neto, 2013= Jiandani, 2018= Ntoumenopoulos, 2014=	*RCT:* Ribeiro, 2019	*RCT:* Boussari, 2014- Tomar, 2019-	*Systematic review:* Rose, 2017=	*Systematic review:* Hewitt, 2016= *RCT:* Hongratta, 2014- *Experimental:* Guner, 2015-	None
	Neurological observations	*Systematic review:* Ferreira, 2013- *Observational:* Neto, 2013=	None	*RCT:* Tomar, 2019-	None	None	None

= Denotes no significant difference between intervention and control/comparison.

+ Denotes significant finding in favour of the intervention compared with control/comparison.

- Denotes significant finding in favour of the control/comparison compared with the intervention.

RCT = randomised clinical trial; MHI = manual hyperinflation; VHI = ventilator hyperinflation.

A summary of the non-experimental research included in this scoping review is provided in Table 2.

Table 2: Summary of non-experimental research.

Method	Author	Country	Aims	Study population
Survey	Hayes 2011	Australia and New Zealand	VHI practice	Physiotherapists
	Bhat 2014	India	Chest physiotherapy in neuro ICU	Physiotherapists (44.3% response)
	Lottering 2016	South Africa	Physiotherapy practice in South African ICUs	Physiotherapists (33.8% response)
	Rose 2016	Canada	Cough augmentation techniques in critically ill	Physiotherapists
	Grammatopoulo 2017	Greece	Physiotherapy services provided in public ICUs	ICU directors and ICU physiotherapists (68.7% response)
	Matilde 2017	Brazil	Bronchial hygiene techniques in ventilated patients	Physical therapists – on call or intensive care specialists
	Newstead 2017	Australia	Critical care nurses' attitudes to traditional chest physiotherapy	Critical care nurses (response rate 12%)
	Rose 2018	Canada and U.K.	Use of airway clearance strategies in NMD and SCI requiring NIV or IMV	Respiratory clinicians across U.K. ($n = 63$) and Canada ($n = 92$)
	Stilma 2021	Netherlands	Airway care interventions for mechanically ventilated patients	ICU clinical representative (92% nurses) (85% response rate)
Delphi	Skinner 2016	Australia and New Zealand	Minimum standards of clinical practice for physiotherapists working in critical care	Experts – clinical and academic physiotherapists >5 years' experience
	Twose 2019	U.K.	Minimum standards of clinical practice for physiotherapists working in critical care	Experts – clinical and academic physiotherapists >3 years experience
	van der Lee 2019	International	Respiratory physiotherapy management of ventilated adults with community acquired pneumonia	Experts – clinical and academic physiotherapy experts

Qualitative	Connolly 2020	U.K.	Airway clearance techniques and use of mucoactive agents for critically ill patients with respiratory failure	Physiotherapists >2 years' experience
	van der Lee 2020	Australia	Clinical validation of expert consensus statements for respiratory physiotherapy management of mechanically ventilated patients	Physiotherapists, nurses, consultant intensivists

ICU = intensive care unit; VHI = ventilator hyperinflation; IMV = invasive mechanical ventilation; NMD = neuromuscular disease; SCI = spinal cord injury; NIV = non-invasive ventilation.

Discussion

The papers retrieved by this deliberately wide-ranging scoping review were diverse and as well as clinical efficacy papers, included assessment of the requirements for airway clearance techniques (ACTs), physiological effects of ACTs, opinions of caregivers, service delivery and clinical recommendations.

Non-experimental research

Clinician opinion regarding airway clearance techniques using surveys of current practice has been the subject of a number of recent studies (18, 19, 20, 21, 22, 23, 24). These surveys have highlighted that a number of varying airway clearance and cough augmentation techniques are used by critical care clinicians. Studies reported heterogeneity of intensity and combination of ACTs in addition to variation in clinical practice. Rationale for commencing airway clearance techniques is similar across studies, including to aid in sputum clearance and promotion of improved alveolar recruitment and ventilation. Some studies highlight that lack of knowledge, training, and expertise may contribute to reduced adoption of techniques such as mechanical in-exsufflation (22) and ventilator hyperinflation (23). Such studies recognise the lack of clinical guidance in this area.

Qualitative studies with physiotherapists and wider critical care clinicians highlight the importance of teamwork, clinical reasoning, clinical experience and communication as key in the selection and effective implementation of airway clearance interventions for mechanically ventilated adults (6, 25).

A recent focus of non-experimental research has been the production of clinical guidelines using a Delphi technique to achieve expert consensus, specifically to identify core clinical competencies for practitioners implementing airway clearance techniques (1, 26) and best practice for the treatment of community-acquired pneumonia (21). Expert consensus panels recognise that physiotherapy competence in airway clearance interventions such as hyperinflation techniques, manual chest wall techniques, positioning, normal saline

instillation and suction are a minimum standard of practice for physiotherapists working in ICU in their respective countries (1, 26). This scoping review did not retrieve any recent clinical guidelines to aid in the selection, implementation or evaluation of airway clearance techniques for non-specific intubated adults.

Experimental research: short-term outcomes

Papers focusing on clinical efficacy investigated interventions that enhanced inspiratory volume and/or expiratory flow. The effects of such airway clearance techniques were primarily reported on short-term outcomes such as oxygenation, sputum yield, respiratory mechanics (for example, dynamic compliance) and peak expiratory flow (PEF; either absolute PEF or peak inspiratory-expiratory flow (PIF:PEF) ratio). Although sputum yield is the most direct outcome measure for the efficacy of airway clearance techniques, oxygenation and respiratory mechanics are reported frequently. Techniques which appear to enhance sputum yield include adjuncts such as high-frequency chest wall oscillation (HFCWO) and oscillatory positive expiratory pressure (OPEP) devices (27, 28, 29, 30), head down positioning (31), and multi-modal chest physiotherapy (13, 32). The evidence for the effect of hyperinflation, manual techniques and cough augmentation on sputum yield is mixed, with contradictory findings. Several studies have reported no difference in effect between manual hyperinflation and ventilator hyperinflation regarding sputum yield, including a systematic review (11).

The most effective interventions to improve oxygenation in the short-term appear to be manual and ventilator hyperinflation with multiple studies reporting statistically significant if not necessarily clinically significant findings in favour of this intervention (12, 33, 34, 35, 36, 37, 38, 39). Improvements in respiratory mechanics such as static and dynamic lung compliance were reported with multi-modal chest physiotherapy by multiple systematic reviews (8, 13, 40). Several experimental studies reported a similar effect with airway clearance adjuncts (27, 41, 42) which seems to be an emerging area of research that warrants further attention.

Animal studies have investigated the effect of airway clearance techniques on PEF, particularly to determine whether the threshold for mucous movement can be achieved by head down positioning and manual techniques (43, 44). A number of clinical studies have also explored this outcome measure with adjuncts (27) and manual techniques (45, 46) being shown to improve PEF.

Cardiovascular and neurological stability have been investigated in a number of studies and whilst some statistically significant deteriorations have been reported during various airway clearance techniques, authors concluded that these were transient and non-clinically significant. This suggests that ACTs are safe for the intubated patient (47, 48).

Experimental research: longer-term outcomes

Longer-term outcome measures such as mortality, ICU length of stay, ventilator-acquired pneumonia (VAP) rates and extubation outcome were reported by some studies although far less frequently than short-term outcomes. Understandably, these longer-term outcome measures have been a focus of systematic reviews (8, 13, 15, 49). With the exception of mortality (49), systematic reviews included in this scoping review report no significant effect of airway clearance techniques on any of these longer-term outcome measures (8, 13, 15).

This scoping review retrieved a number of experimental studies reporting reduced VAP rates with airway clearance adjuncts (30, 50), head-down positioning (43), manual techniques (51) and multi-modal chest physiotherapy (34, 52). Similarly, an improved likelihood of extubation success has been reported in some studies with cough augmentation (53) and multi-modal chest physiotherapy (54). Whilst quality was not assessed as part of this scoping review, these findings suggest that the effect of airway clearance techniques on VAP rates and extubation outcome may warrant further investigation.

Limitations of this scoping review

This scoping review was intentionally limited to airway clearance techniques that are typically delivered by respiratory physiotherapists in the adult ICU. Due to this, some aspects of airway clearance such as routine suctioning, humidification, regular repositioning, bronchoscopy and pharmacological interventions were not included.

A major methodological limitation was the lack of quality assessment of the included papers. Due to the wide-ranging remit of the review and number of papers retrieved, this was beyond the scope of this review and was not deemed necessary in order to meet the aims and objectives set out in advance. Randomised clinical trials were carefully screened and if they failed to meet the criteria for randomisation as described by PEDro (55), they were classified as 'other experimental' studies.

Future research

Future experimental research is still required to determine the effectiveness of airway clearance techniques in the intubated adult. Existing randomised clinical trials have focused on short-term outcomes and therefore a reasonably comprehensive body of evidence is available for common interventions such as hyperinflation and manual techniques in this regard. There are emerging interventions with an increasing evidence-base such as cough augmentation and airway clearance adjuncts. As an outcome measure, PEF appears to be influenced by ACTs, however its relevance to other, more clinical outcomes would benefit from further experimental investigation. Another under-researched area is positioning for airway clearance, despite this being a routinely used intervention for intubated adults (20). A focus for future research should be the effect of airway clearance on longer-term outcomes, particularly VAP rate and extubation success as these appear to be outcomes that may be influenced by ACTs.

Future reviews should be carefully considered and rationalised. There would be merit in an updated systematic review investigating the effect of manual techniques as several recent studies have not yet been captured by such a review. Furthermore, airway clearance adjuncts for the intubated patient have not yet been investigated by systematic review and this may be an area that warrants the same. A plethora of narrative reviews on this topic are already available and therefore any future narrative reviews should have a clear and unique focus.

Conclusion

This scoping review was undertaken as an area of priority for the ACPRC editorial board. The extent of the available evidence regarding airway clearance for intubated adults has been summarised, thus achieving the aim of the scoping review. Included papers were diverse and wide-ranging in their findings. Overall, the evidence-base regarding the efficacy of airway clearance techniques for short-term clinical outcome measures is moderately large. Currently, there is limited evidence regarding their efficacy for longer-term outcome measures. There is a moderate body of evidence reporting that airway clearance techniques are safe for the intubated adult.

Future clinical research should focus on the effects of airway clearance techniques on longer-term outcome measures such as VAP rates and extubation outcome as well as investigating common but under-researched interventions such as positioning. As the quality of the studies was not assessed in this scoping review, future work is needed to develop clinical recommendations based on both short- and long-term efficacy of airway clearance techniques for adults who are intubated.

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Conflicts of interest

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Life after critical illness: a systematic review and thematic synthesis protocol

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Background

Survivorship following critical illness can be the beginning of a challenging and prolonged recovery. Patients, many of whom are elderly and frail (1), require supportive therapies such as ventilation, other organ support devices, sedation and experience immobility. These factors can contribute to long-term musculoskeletal impairments resulting in decreased exercise tolerance, loss of muscle strength, chronic pain, and shoulder impairment (2, 3). Subsequently, patients often experience functional impairments limiting their activities of daily living, and leading to a long-term reduction in health-related quality of life (HRQoL). This includes unemployment, increased healthcare utilisation and unplanned hospital readmissions (4). Inability to return to work persisted across a five-year follow-up period for 31% of patients with acute respiratory distress syndrome (5).

Beyond the physical impairments, the biopsychosocial impact of ongoing ill health can be an overwhelming burden for patients. Depression and post-traumatic stress disorder (PTSD) are the primary psychological symptoms that can lead to a long-term reduction in HRQoL. Mores so, psychosocial impairments are classified as an unacceptable patient-reported outcome following critical illness. Similarly, the consequences of the patients' ill

health also adversely impacts their families. This ranges from financial dependence, transitioning to the care giver role and their own psychological distress (6).

For healthcare professionals to deliver optimal rehabilitation services, it is essential to understand the patients' experiences of recovery from critical illness, and what it means to 'recover'. For example, what are the components of functional recovery that patients consider as important and therefore are likely to engage with? This will allow healthcare professionals to deliver patient centred care through their assessments and interventions which should be seen as fundamental to recovery. Given the profound and lasting impairments associated with critical illness, the impact of these need to be explored beyond the acute hospital, to include the transition and reintegration into the community setting (7). A qualitative evidence synthesis will help us to understand the experience of transition and reintegration into the community in order to improves outcomes and experiences following critical illness. To our knowledge, a systematic review on this topic has not been undertaken. Our findings will support future qualitative research focusing beyond hospital discharge to contribute to the development of a complex intervention to improve the long-term musculoskeletal health of survivors of critical illness, and shared decision making.

The search strategy tool of SPIDER (*sample*, *phenomenon of interest*, *design*, *evaluation*, *research type*) (Table 1) was used to develop and refine the key components of the review questions (8). Our systematic review questions are:

1 What are the experiences of critical care survivors living with physical impairments beyond hospital discharge?
2 What are the experiences of family and staff supporting critical care survivors living with physical impairments beyond hospital discharge?

Table 1: A SPIDER tool for these research questions.

S: sample	Patients, family or staff supporting
P of **I**: phenomenon of interest	Adult survivors of critical care
D: Design	Any qualitative design; or mixed methods with primary qualitative
E: Evaluation	Experiences, views, thoughts, perceptions
R: Research type	Qualitative

Objective

Our primary aim of this review is to identify and synthesise primary qualitative studies exploring the experiences of critical care survivors living with physical impairments beyond hospital discharge. Our secondary aim is to identify and synthesise primary qualitative research of experiences of family and healthcare staff supporting critical care survivors living with physical impairments beyond hospital discharge.

Methods

This protocol was prepared using the Preferred Reporting Items for Systematic Review and Meta-analysis Protocols (PRSIMA-P) (9). This systematic review has been registered with PROSPERO (the international prospective register of systematic reviews): CRD42022306578.

Eligibility

For inclusion, studies must explore experiences of adult (18 years or older) survivors of critical illness experiencing physical impairments beyond hospital discharge. Similarly, studies that explore experiences of families supporting or caring for; or staff signposting or providing rehabilitation services to adult survivors of critical illness experiencing physical impairments beyond hospital discharge will also be included. Staff groups are not limited to a specific profession. Studies will be excluded if any participants are under the age of 18 or adolescent; or if they are paid caregivers and relatives to this patient group. We will include primary qualitative research studies or mixed-methods studies using primary qualitative data. We will only include studies published in English.

Data source

Multiple databases will be searched, including Allied and Complementary Medicine database (AMED), Cumulative Index of Nursing and Allied Health Literature (CINAHL), Embase, PubMed and Physiotherapy Evidence Database (PEDro). Grey literature will also be searched including Open Grey, clinicaltrials.gov, pre-print servers and hand searching of Google Scholar.

Search strategy

Search terms have been developed with a university librarian to produce the following search strategy which focuses on survivors of critical illness. The principal search terms will include (critical illness or intensive care or (ICU or ICUs or ITU) or adult respiratory distress syndrome or ARDS or critical* ill*) and (qualitative or 'mixed methods'). Accordingly, search terms or (Medical Subject Heading) MeSH terms will be utilised for individual databases as necessary.

Data selection

Outputs from searches of each database will be imported into Rayyan software (10), and any duplicate publications will be removed. Studies will be assessed for inclusion (against eligibility criteria) independently by two reviewers at title and abstract. Remaining studies will be independently assessed by two reviewers at full text. At both stages, if disagreements cannot be resolve through discussion, a third reviewer will add to the discussion. Data selection will be presented in a PRISMA flowchart (Figure 1).

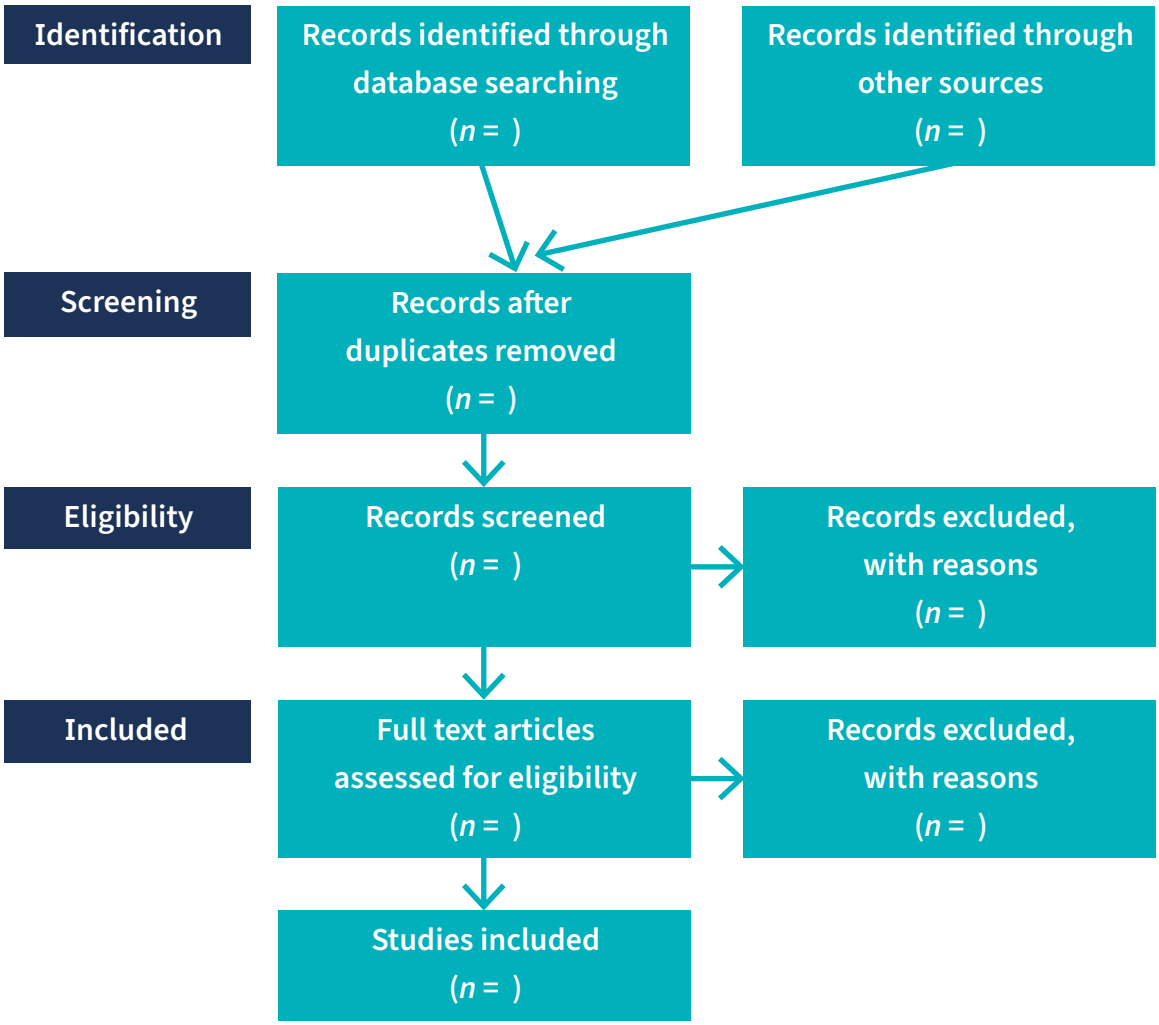

Figure 1: PRISMA flowchart.

Data extraction

For all studies, data will be extracted including study design (including qualitative methodology), qualitative data collection (for example, interviews or focus groups with participant numbers), participant characteristics (for example, patient, relative, staff), study aims, interview time point and reviewer's initial comments. This will be undertaken and recorded on data extraction tables within Microsoft Excel by the first reviewer and checked by second reviewer. Subsequently, NVivo (version 12), a qualitative data analysis software package will be used to allow for data extraction of study findings, concepts and contextual information; overaching themes will be defined in NVivo too, in order to allow for the inductive generation of codes and themes.

Quality appraisal of studies

All studies included within the review will be assessed for quality using the *Critical Appraisal Skills Programme – qualitative checklist* (11) independently by two reviewers. CASP – qualitative, which is endorsed by Cochrane Qualitative and Implementation Methods Group is the most commonly tool for quality appraisal in health-related qualitative evidence synthesis (QES) (12).

Data synthesis

Thematic synthesis is derived from thematic analysis which analyses primary qualitative research data. Thematic synthesis has three stages:

- The coding of text line by line.
- The development of descriptive themes.
- The generation of analytical themes (13).

The first reviewer will undertake all three stages of thematic synthesis with NVivo. This will be an iterative process and therefore developed in discussion with all authors. The preliminary themes will be further distilled until final themes are agreed.

Confidence in cumulative findings

Confidence in the findings of this review will be assessed according to GRADE CERQual (Confidence in the Evidence of Qualitative research) (14). GRADE CERQual assesses the confidence of findings from a review which is the extent of which the findings are a reasonable representation of the phenomenon. The 4 components for consideration are:

- Methodological limitations.
- Coherence.
- Adequacy of data.
- Relevance.

Confidence ratings are classified as high, moderate, low or very low.

Two reviewers in collaboration will undertake the assessment of GRADE CERqual due to the subjective nature of the judgements. The confidence ratings for each theme will be recorded in a table using the *GRADE CERQual Interactive Summary of Qualitative Findings* tool.

Reflexivity

As qualitative research risks elements of subjectivity; it is essential reflexivity is acknowledged. Reflexivity details how researchers demonstrate an awareness of their role across the research processes (15). Five authors are physiotherapists (Elizabeth King, Owen Gustafson, Sarah Vollam, Francine Toye and Mark Williams), including two who work within critical care (Elizabeth King and Owen Gustafson) and one author is a nurse, who is a critical care researcher (Sarah Vollam). One author (Francine Toye) is an expert in qualitative research. With particular care at times of key decision-making and analysis, time will be invested to discuss our pre-conceptions and work as a group on interpretation and analyses.

Discussion

This systematic review with thematic synthesis will explore the experiences of:

1 Adult survivors of critical illness, in particular those who experience physical impairment which might impact their participation in life.
2 Their family members and health workers involved in their care and rehabilitation.

This synthesis of qualitative research is likely to provide insight into a range of factors that have an impact on a person's recovery following critical illness at family and service provider levels.

Identifying the literature base is the initial element of the development phrase for designing a complex intervention (16). The findings of this review will synthesise the experiences of key stakeholders, and identify any gaps in the existing literature. This will contribute to the theoretical development stage whereby primary research can be undertaken through interviewing key stakeholders. A complex intervention is needed to optimise the rehabilitation for survivors of critical care as trials have yet to demonstrate intervention with fully understood endpoints. This is coupled with a lack of understanding of the experiences and motivators of patients to engage with the treatments.

Whilst exploring and identifying the literature, we believe this topic of interest is one of trustworthiness due to the significance of real world impact for patients, their families and staff. We will explore the credibility of the literature and similarly consider the transferability of the findings to the critical care populations nationally (17).

Key points

1 Functional impairments are commonly experienced following periods of critical illness.
2 These can negatively impact long-term reduction in health-related quality of life, unemployment, and lead to increased healthcare utilisation.

The synthesis of literature for survivors of critical illness beyond hospital discharge is yet to be undertaken.

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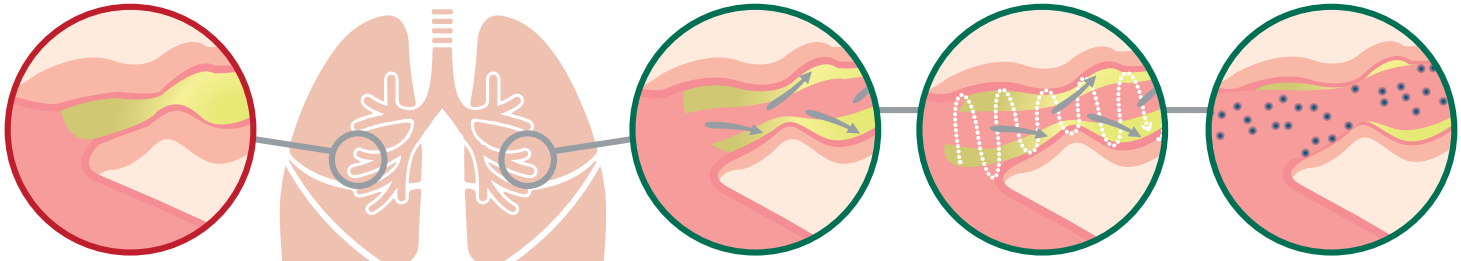

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