High Frequency Chest Wall Oscillations (HFCWO)
& Mechanical Insufflation–Exsufflation (MI-E) Pathway

This document recommends criteria to be used across Coventry and Warwickshire when requesting funding for high frequency chest wall oscillations (HFCWO) and mechanical insufflation-exsufflation (MI-E) for individual patients alongside the available evidence base. These devices are provided as standard treatment in some areas for individuals with neuromuscular disease (NMD) based on recommended standards of care (20, 22, 27, 29).

HFCWO and MI-E are types of airway clearance techniques used by respiratory physiotherapists to enhance clearance of excess bronchial secretions, to try and minimise infection and therefore prevent repeated lung damage. The child/young person (CYP) specific use of these treatment techniques can be taught by a respiratory physiotherapist, to nurses, support workers, carers and families using a respiratory physiotherapy treatment plan as part of a competency training package.

If a health care professional feels the HFCWO/MI-E may be beneficial for the CYP, they must discuss with multidisciplinary team (MDT) including the respiratory physiotherapist. A respiratory assessment must be carried out by a respiratory physiotherapist. If a community respiratory physiotherapist is not available, funding for a formal assessment by a respiratory physiotherapist must be agreed by CCG. Device costs are detailed in appendix 1.

Device	**Cost of Equipment** (excluding VAT)	**1 year supply consumables**	**Rental costs**	**Warranty**	**Trial Loan period**
Nippy Clearway Breas Medical (MI-E device)	£3300.00	£160.00	£190.00 per month, minimum rental 12 weeks	1 year	2 months
E70 Cough Assist Philips (MI-E device)	£3,436.51 - £3,702.91	£33.28	£380.00 per month	1 year	1 month
The Vest Hill-Rom (HFCWO device)	£6,995.00	No initial cost	£10.00 per day minimum rental 3 month	2 year	3 months

1. Initial assessment for HFCWO/MI-E

The CYP should be assessed by a respiratory physiotherapist (acute or community). The choice of airway clearance technique is decided by the respiratory physiotherapist and the CYP/CYP's family. Before starting, there must be clear indications and evidence of other airway clearance techniques that have been tried and have not been effective.

Criteria for HFCWO:

The HFCWO is used to facilitate airway clearance of secretions in CYPs who have acute and chronic respiratory conditions. The HFCWO rapidly inflates and deflates the vest compressing and releasing the chest wall causing high frequency oscillations which replicate mini-coughs. These mini coughs, dislodge the mucus from the wall of the airways and with the increased strength of the ciliary beat through resonance, helps transport it to the larger central airways for clearance.

HFCWO may be considered:

- Acute chest infection with secretion retention
- Chronic mucus hypersecretion or secretion retention associated with a chronic pulmonary or neuromuscular condition
- Alternative airway clearance therapy proven ineffective or contraindicated e.g. persistent atelectasis despite normal airway clearance
- Long term ventilated with evidence of secretion retention
- Ongoing fatigue despite the initiation of NIV, lack of strength or ability to perform active respiratory physiotherapy treatment e.g. active cycle of breathing
- Symptomatic e.g. daily secretion retention, recurrent respiratory infections, SpO2< 95% due to secretion retention, frequent hospitalisations e.g. three or more per annum, HDU and PICU admissions, decline in lung function, regular antibiotics / steroids required for chest infections
- Prolonged absence from school due to chest infections.
- High burden of care e.g. siblings with additional healthcare needs, other dependants / commitments, carer disability, significant dependence on chest physiotherapy need, reliance on others to assist with mucus clearance and physical demand on patient and carers to perform treatment.

(1-17, 36).

Appendix 2 has charts to show the criteria indicated and total number of criteria for using HFCWO in CYP in Coventry and Warwickshire Partnership Trust (CWPT) and other areas between March 2017 and May 2018.

In CWPT, there are 3 CYP who required HFCWO and the total number of criteria indicated was between 5 and 8. Data was also collected on the use of HFCWO from other physiotherapists across the UK working in the acute sector and community. The total number of criteria indicated from other areas was between 3 and 8. During this data collection it became evident that HFCWO is not widely used by the other trusts, and so it was decided to only use the data from CWPT as 3 CYP are using the HFCWO. It is therefore recommended that if a CYP in CWPT meets 5 or more of the criteria, HFCWO may be considered. This is only a guide and clinical reasoning should be applied when selecting appropriate airway clearance devices for the CYP.

Criteria for MI-E:

Ineffective cough is a major cause of mortality and morbidity in CYP with NMD. This leads to recurrent pulmonary infection which causes progressive lung damage and poor respiratory function; and eventually respiratory failure. MI-E is used as a device to aid CYP to clear retained broncho-pulmonary secretions. MI-E is also used with CYP who have decreased inspiratory effort, due to either spinal cord injury or NMD; and who have an impaired or ineffective cough with appropriate respiratory symptoms. MI-E is considered when conventional cough assistance techniques (e.g. breath stacking, manual assisted cough) become ineffective. MI-E inflates the lungs with gradual positive airway pressure followed by a rapid switch to negative airway pressure. This simulates the flow changes that occur during a cough, and assists clearance of secretions.

MI-E may be considered:

- Acute chest infection e.g. chest exacerbation, increase in sputum
- Chronic mucus hypersecretion or secretion retention associated with a neuromuscular condition
- Ineffective cough or inability to remove mucus by coughing. Indications for starting cough assistance techniques for CYP with neuromuscular weakness:
    - In CYP, who are able to perform a reproducible forced expiratory flow manoeuvre, a forced vital capacity <50% of predicted is an indication for MIE.
    - In adults with neuromuscular weakness, a PCF (peak cough flow) >160 litres/min is necessary for effective secretion clearance and a PCF >270 litres/min is associated with resilience to respiratory infection. The minimum PCF accepted as normal is 400 litres/min and is reached between 12-13 yrs. Therefore indicated:
        - In children>12yrs who have a PCF<270 litres/min, particularly if they have had episodes of deterioration with respiratory infection.
        - In children>12yrs, PCF <160 litres/min is a strong predictor of severe chest infections, respiratory failure and indicate that CYP should start assisted coughing methods, even in the absence of respiratory complications in the medical history
- Where breath stacking and/or manual assisted cough proven ineffective or contraindicated e.g. osteopenia, persistent atelectasis despite normal airway clearance
- Long term ventilated with evidence of secretion retention
- Clinical evidence of hyperinflation and/or air trapping
- Ongoing fatigue despite the initiation of NIV, lack of strength or ability to perform active respiratory physiotherapy treatment.
- Symptomatic e.g. daily secretion retention, recurrent respiratory infections, SpO2< 95% due to secretion retention, frequent hospitalisations e.g. three or more per annum, HDU and PICU admissions, decline in lung function, regular antibiotics / steroids required for chest infections
- Prolonged absence from school due to chest infections.

- High burden of care e.g. siblings with additional healthcare needs, other dependants / commitments, carer disability, significant dependence on chest physiotherapy need, reliance on others to assist (18-36).

Appendix 2 has charts to show the criteria indicated and total number of criteria for using MIE in CYP in CWPT and other areas between March 2017 and May 2018.
In CWPT, there are 4 CYP who required MI-E and the total number of criteria indicated was between 6 and 9. The total number of criteria from other areas varied between 3 to 9. MI-E is a more commonly used device and data showed across the areas on average, the minimum number of criteria indicated for using MI-E was 5 or more.
It is therefore recommended that if a CYP in CWPT meets 5 or more of the criteria, MI-E may be considered. This is only a guide and clinical reasoning should be applied when selecting appropriate airway clearance devices for the CYP.

2. Trial Period

The HFCWO/MIE should only be set up and modified by a trained respiratory physiotherapist. The Respiratory Physiotherapist's role will include:

- Gaining agreement from the Lead consultant – community / acute. There needs to be an agreement that this level of treatment is appropriate for long term use for the CYP considering factors such as palliation before being discussed with CYP and family.
- Gaining consent and communication with CYP and family
- Informing Community Children's Nurse (CCN) and continuing care group / health panel.
- If device started by respiratory physiotherapist in tertiary centre, need to liaise with community respiratory physiotherapist. If community respiratory physiotherapist service unavailable, need to consider how the CYP and device will be monitored in the community.
- If recommendation is part of a new continuing cares assessment, the respiratory physio will provide the information to the CCN to include in the CYP assessment.
- Inform other health care professionals involved in CYP care as appropriate.
- Arrange loan equipment from Hill-Rom, Philips, Nippy by completing loan request form if appropriate.
- Provide child specific respiratory physiotherapy treatment plan to include back up treatment if HFCWO/MI-E breaks. To be written by respiratory physiotherapist.
- Arrange training and complete child specific competencies for carers / family members by respiratory physiotherapist.
- Consider where HFCWO/MI-E will be set up and used: home / School / nursery / hospital / hospice.
- Respiratory Physiotherapist to deliver training and complete child specific competencies for carers / family members
- Provide CYP family with contact numbers for respiratory physio and who to contact for consumables if required.
- If renting device, additional consumables will need to be added to rental costs.
- Provide equipment manual & cleaning instructions plan.

Outcome measures: During the assessment at the beginning of the trial by the respiratory physiotherapist, appropriate outcome measures will be defined to get the best objective feedback on the effectiveness of the treatment during the trial period. Appropriate members of the family or care team will be asked to record these objective measures to enable the respiratory physiotherapist to assess the results of the trial.
The following is an example of some objective measures that might be used:

Short Term measures

- Observation of respiratory pattern & rate
- Auscultation
- Oxygen saturations
- Cough
- Peak cough flow
- Sputum
- Ventilator settings
- Oxygen requirement
- Number of suctions / catheters used

Long Term measures

- Lung function test (as they get older and if able)
- Chest x-ray if able
- Compliance and CYP perspective
- Length of treatment
- Exercise tolerance
- Microbiology
- Number of hospital admissions
- Number of respiratory infections
- Number of courses of antibiotics for respiratory infection
- Ease of teaching / learning
- Burden of care
- Number of carers required to perform treatment
- Costs (direct and indirect to be evaluated prior to starting device e.g. length of hospital stay with associated ward, HDU or PICU bed costs, antibiotic courses and costs.

3. Trial Successful

The respiratory Physiotherapist to inform:

- CCN and continuing care group / health panel.
- Company and request a formal quote including consumables for a year and servicing / warranty.
- Once funding agreed by CCG, inform health care professionals involved as appropriate.

Once purchased, HFCWO/MI-E to have asset number and PAT tested as required by trust policy.
Ongoing monitoring, training of family / carers, CYP assessment and competency yearly review by acute or community respiratory physiotherapist.
Annual service and maintenance of equipment as per manufacturer's guidance.
Ensure provision of consumables

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Emily Parry, Community Children's Nurse, South Warwickshire NHS Foundation Trust

Donna Powell, Lead nurse for Children's Continuing Care, South Warwickshire NHS Foundation Trust

Louise Bridges, Service Manager, CYP Complex Physical Health Services Child and Family Services, CWPT

Association of Paediatric Charted Physiotherapist (APCP) respiratory committee:
Lauren Williams, Advanced Physiotherapist, Sheffield Children's Hospital
Sheona Stubbs, Team Lead Paediatric Physiotherapist, Serennu Children's Centre, Newport
Jo Thornton, Specialist Paediatric Physiotherapist, Burnley Hospital
Rachel Evans, Independent Paediatric Respiratory Physiotherapist
Zoe Johnstone, Clinical Specialist Respiratory Physiotherapist, RHSC Edinburgh

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Nicky McNarry, Regional LTV Clinical Specialist Physiotherapist, Nottingham Children's Hospital
Nic Rutter, Continuing Care Team Specialist Physiotherapist, Derby Children's Hospital

Dr Michelle Chatwin, Consultant Physiotherapist, Royal Brompton Hospital.

HFCWO References

1. Anbar RD (1998) Compliance with use of ThAIRapy Vest by patients with cystic fibrosis, Paediatric Pulmonol 1998 (suppl 17):346,A497
2. Anbar RD. (1999) Use of ThAIRapy® Vest does not affect liver function of patients with cystic fibrosis. Am J Respir Crit Care Med; 159(3), A687.
3. App et al (1998) Physiotherapy and mechanical breakdown of the excessive DNA load in CF sputum- an anti-inflammatory therapeutic strategy, Paediatric Pulmonology, suppl 17; 349, A507.
4. Butler S, O'Neill B (1995) High frequency chest compression therapy: a case study. Pediatr Pulmonol;19: 56-59.
5. Burnett et al (1993) Comparative efficacy of manual chest physiotherapy and a high frequency chest compression vest in inpatient treatment of cystic fibrosis, Am Rev Respir Dis 1993;(suppl 147):A30
6. Castagnino M, Vojtova J, Kaminski S, Fink R (1996) Safety of High Frequency Chest Wall Oscillation in patients with respiratory muscle weakness. Chest; 110: S65.
7. Chiappetta A, Beckerman R (1995). High Frequency Chest Wall Oscillation in spinal muscular atrophy (SMA). RT J Respir Care Pract; 8(4): 112-114.
8. Gomez A, Elisan I, Hardy K (2000) High Frequency Chest Wall Oscillation: video documentation of effect on a patient with duchenne's muscular dystrophy and severe scoliosis. Poster presentation at the 46th International Respiratory Congress of the American Association for Respiratory Care, October 7,Cincinnati, Ohio, USA.
9. Hansen et al (1990) High frequency chest compression system to aid in clearance of mucus from the lung. Biomed Instrum Technolo, 24, pp289- 294
10. Kluft et al (1996) A comparison of bronchial drainage treatments in CF,Paediatric Pulmonol, Oct 1996, 22(4), p271-4
11. Ndukwu et al (1999) Comparison of HFCWO and manual chest therapy in long term acute care hospital ventilator- dependant patients, Chest, 116
12. Oermann CM et al (2001) Comparison of HFCWO and oscillating PEP in home management of CF:a pilot study, Paediatric Pulmonol v32,no.5,Nov, p372-377
13. Piquet J, Brochard L, Isabey D, De Cremoux H, Chang HK, Bignon J, Harf A. (1987) High frequency chest wall oscillation in patients with chronic airway obstruction, Am Rev Respiratory disease, 136, pp 1355-1359
14. Perry RJ, Man GCW, Jones RL (1998) Effects of positive end-expiratory pressure on oscillated flow rate during high frequency chest compression. Chest; 113(4): 1028-1033.
15. Robinson et al (1992) Evaluation of a high frequency chest compression device in cystic fibrosis, Paediatric Pulmonol 1992;(suppl 8):304,A225
16. Whitman et al (1993) Preliminary evaluation of high frequency chest compression for secretion clearance in mechanically ventilated patients. Respiratory Care, 38 (10), pp1081-108
17. NICE: The Vest for delivering high-frequency chest wall oscillation in people with complex neurological needs: Medtech innovation briefing (2018)

MI-E References

18. Anderson et al. Systematic review of techniques to enhance peak cough flow and maintain vital capacity in neuromuscular disease: the case for mechanical insufflation-exsufflation. Physical Therapy Review 2005;10: 25-35
19. Bach JR. Amyotrophic lateral sclerosis: prolongation of life by non invasive respiratory AIDS. Chest. 2002; 122(1) 92-8
20. Birnkrant (2018) Diagnosis and management of Duchenne muscular dystrophy, part 2: respiratory, cardiac, bone health, and orthopaedic management. Lancet Neurology, vol 17
21. British Thoracic Society Guideline for respiratory management of children with neuromuscular weakness; Jeremy Hull, Roona Aniapravan, Elaine Chan, Michelle Chatwin, Julian Forton, Jayne Gallagher,Neil Gibson, Jill Gordon, Imelda Hughes, Renee McCulloch, Robert Ross Russell, Anita Simonds, Thorax; July 2012, vol 27
22. British Thoracic Society / ACPRC guidelines; Physiotherapy management of the adult, medical spontaneously breathing patient May 2009
23. Consensus Statement on Standard of Care for Congenital Muscular Dystrophies (2010) Journal of Child Neurology 25(12) 1559-1581
24. CWPT: Community – Children and Young People: Clearway Mechanical Insufflation- Exsufflation Clinical Procedure
25. Fauroux B, Guillemot N, Auberton G, Nathan N, Labit A, Clement A, et al. Physiologic benefits of mechanical insufflation-exsufflation in children with neuromuscular diseases. Chest. 2008; 133(1): 161-8.
26. Finkel et al (2018) Diagnosis and management of spinal muscular atrophy: Part 2: Pulmonary and acute care; medications, supplements and immunizations; other organ systems; and ethics. Neuromuscular Disorders 28, 197–207
27. Guerin C:Bourdin G: Leray V; Delannoy B; Bayle F; Germain M; Richard JC (2011) performance of the cough assist insufflations-exsufflation device in the preseance of an endotracheal tube of trachesotomy tube: a bench study. Respiratory Care; August; vol 56, vol 56,no.8.
28. Kravitz, R. (2009). Airway clearance in Duchenne Muscular Dystrophy. Pediatrics, 123(Suppl 4)
29. NHS England's service specification for neurosciences: specialised neurology (adult)D04/S/a - Annex B includes children 2013
30. Respiratory Care of the Patient with Duchenne Muscular Dystrophy: ATS consensus Statement. Am J Respir Crit Care Med. 2004 August 15, 2004: 170 (4) 456-65
31. Toussaint M (2011).The use mechanical insufflations-exsufflation via artificial airways. Respiratory Care; August; vol 56,No 6.pp1217-9.
32. Wang, C et al (2007) Consensus Statement for Standard of Care in Spinal Muscular Atrophy, Journal of Child Neurology, Volume 22 Number 8, August 2007 1027-1049
33. Winck, JC, Goncalves, MR, Lourenco, C, et al Effects of mechanical insufflation-exsufflation on respiratory parameters for patients with chronic airway secretion encumbrance. Chest 2004;126,774-780
34. Winck, JC, Goncalves, MR. Commentary: Exploring the potential of mechanical insufflation–exsufflation Breathe, June 2008, Vol 4, No 4
35. Winfield, N. (2014). Non-pharmaceutical management of respiratory morbidity in children with severe global developmental delay. The Cochrane Database of Systematic Reviews
36. Chatwin, M et al (2018) Airway clearance techniques in neuromuscular disorders: A state of the art review, Respiratory Medicine 136, 98-100

Appendix (1)

Quotes (March 2018)

Nippy Clearway Breas Medical (MI-E device): (excluding VAT)

- Cost of equipment: £3300.00 with starter pack.
- 1 Year supply of consumables: Mask, Tube and filter box of 12 for 1 year £160.00. Replace monthly. This may vary depending on local infection control policy.
- Rental costs: £190.00 per month includes device and consumables. Minimum 12 weeks rental. No daily rental option
- Warranty: 1 year
- Servicing options: Different options. Bronze service (annual Service with no loan device) £150.00, Silver £500.00 and Gold £780.00. May be able to be serviced locally.
- Trial Loan period: 2 months no charge

E70 Cough Assist Philips (MI-E device): (excluding VAT)

- Cost of equipment: £3,436.51 or £3,702.91 with battery, circuits x 12 and filters
- 1 Year supply of consumables: circuit, interface and filter per pack £16.64 so x2 £33.28 per year. Replace 6 monthly. This may vary depending on local infection control policy.
- Rental costs: £380.00 per month
- Warranty: 1 year
- Servicing options: Different options. Bronze service £255.00, Silver £340.00 and Gold £298.00 for 1st year. May be able to be serviced locally.
- Trial Loan period: 1 month no charge

The Vest Hill-Rom (HFCWO device): (excluding VAT)

- Cost of equipment: £6,995 for unit (air pulse generator), hoses, two permanent garments, remote, manual and blue bag.
- 1 Year supply of consumables: Permanent garments (£275-295.00 each) and hoses (£25.00 set) should last 2-3 years.
- Rental costs: £10.00 per day with minimum rental 3 month period
- Warranty: 2 years
- Servicing options: Fixed price repair £399.00. Different options from £245.00 to £358.00 excluding VAT. May be able to be serviced locally.
- Trial Loan period: 3 month no charge

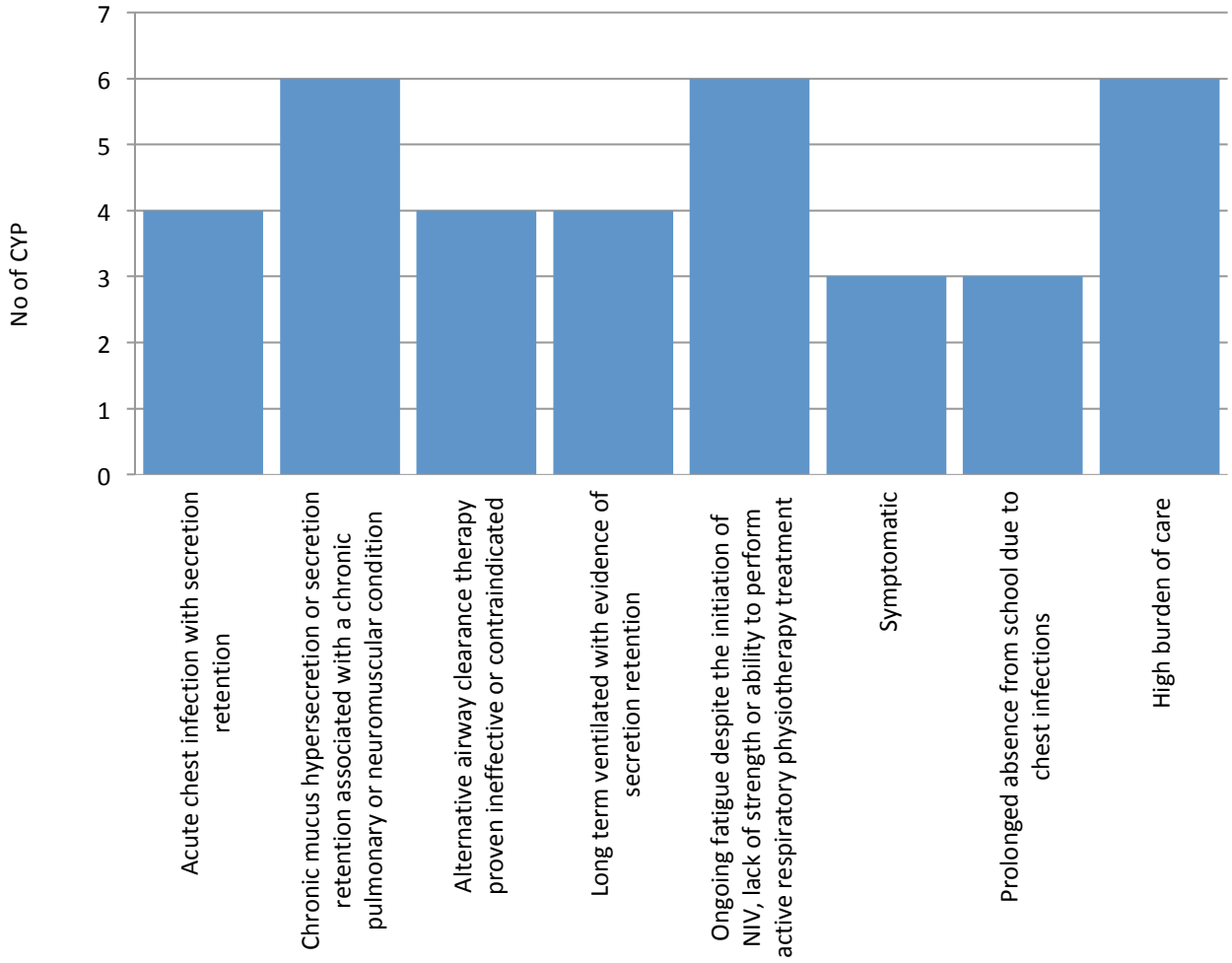
Funding across UK

There are large variations in how equipment is funded across services in England, Scotland and Wales. This may depend on local CCG agreements.

- In Scotland and Wales, do not apply for funding for equipment such as ventilators and cough assist. May be provided by tertiary centre.
- UHNM have a CCG funding agreement for cough assists

Appendix 2

A chart to show the criteria indicated for using HFCWO in CYP in CWPT and other areas between March 2017 and May 2018.



A total of 6 CYP were used in this survey. The chart shows the criteria indicated for using HFCWO in every CYP were:

- Chronic mucus hypersecretion or secretion retention associated with a chronic pulmonary or neuromuscular condition
- Ongoing fatigue despite the initiation of NIV, lack of strength or ability to perform active respiratory physiotherapy treatment
- High burden of care

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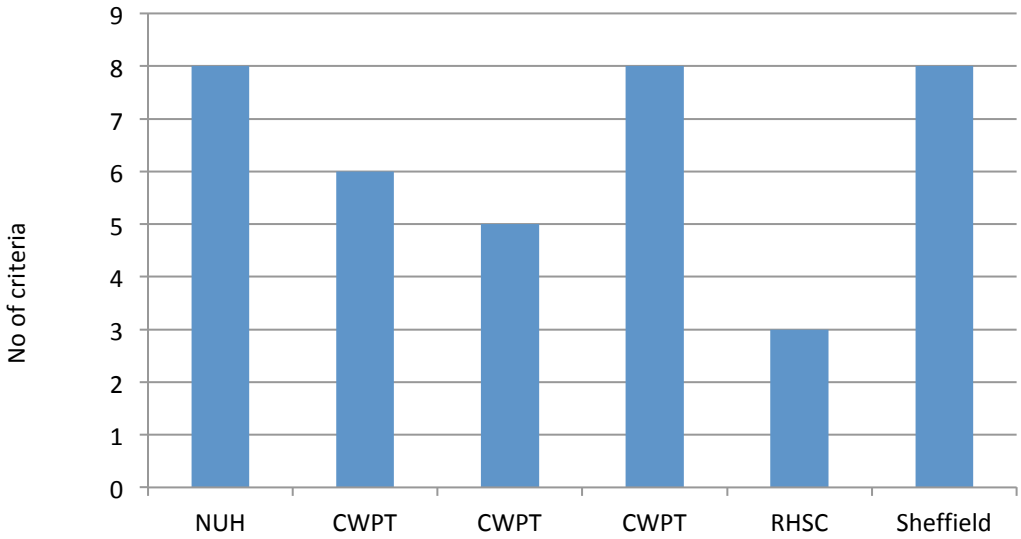
A chart to show the total number of criteria indicated for using HFCWO in CYP in CWPT and other areas between March 2017 and May 2018.



Each column represents one CYP in an area.
In CWPT, there are 3 CYP who required HFCWO and the total number of criteria indicated was between 5 and 8.
The data was collected from other physiotherapists across the UK working in acute and community sectors. The total number of criteria indicated from other areas was between 3 and 8. HFCWO is not widely used and so it was decided to use the data from CWPT as 3 CYP are using the HFCWO. If a CYP in CWPT meets 5 or more of the criteria, HFCWO may be considered. This is only a guide and clinical reasoning should be applied when selecting appropriate airway clearance devices for the CYP.

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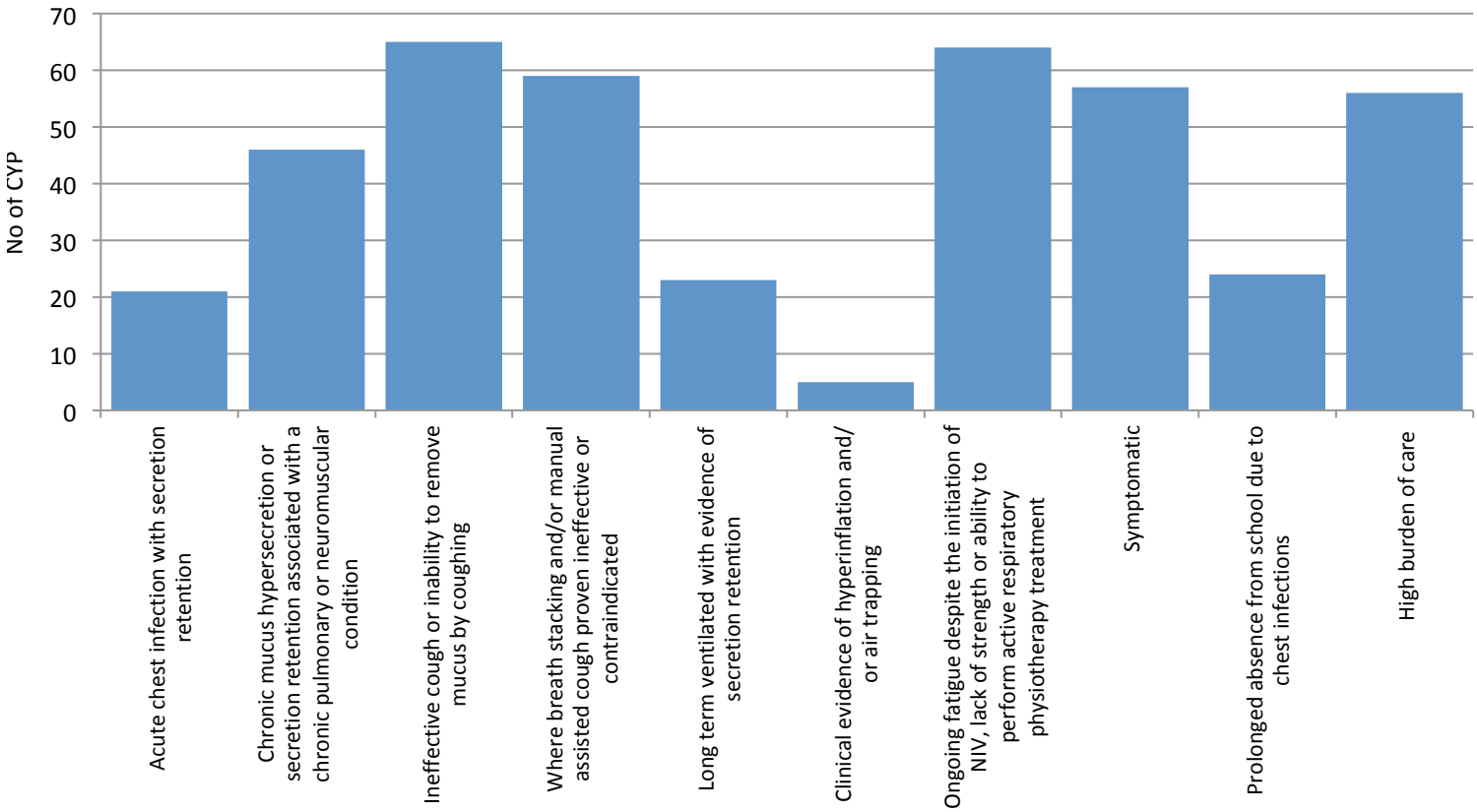
A chart to show the criteria indicated for using MIE in CYP in CWPT and other areas between March 2017 and May 2018.



A total of 65 CYP were used in this survey. The chart shows the criteria indicated in every CYP for using the MIE was:

- Ineffective cough or inability to remove mucus by coughing

The next most common criteria indicated for using the MIE were:

- Ongoing fatigue despite the initiation of NIV, lack of strength or ability to perform active respiratory physiotherapy treatment
- Where breath stacking and/or manual assisted cough proven ineffective or contraindicated
- High burden of care

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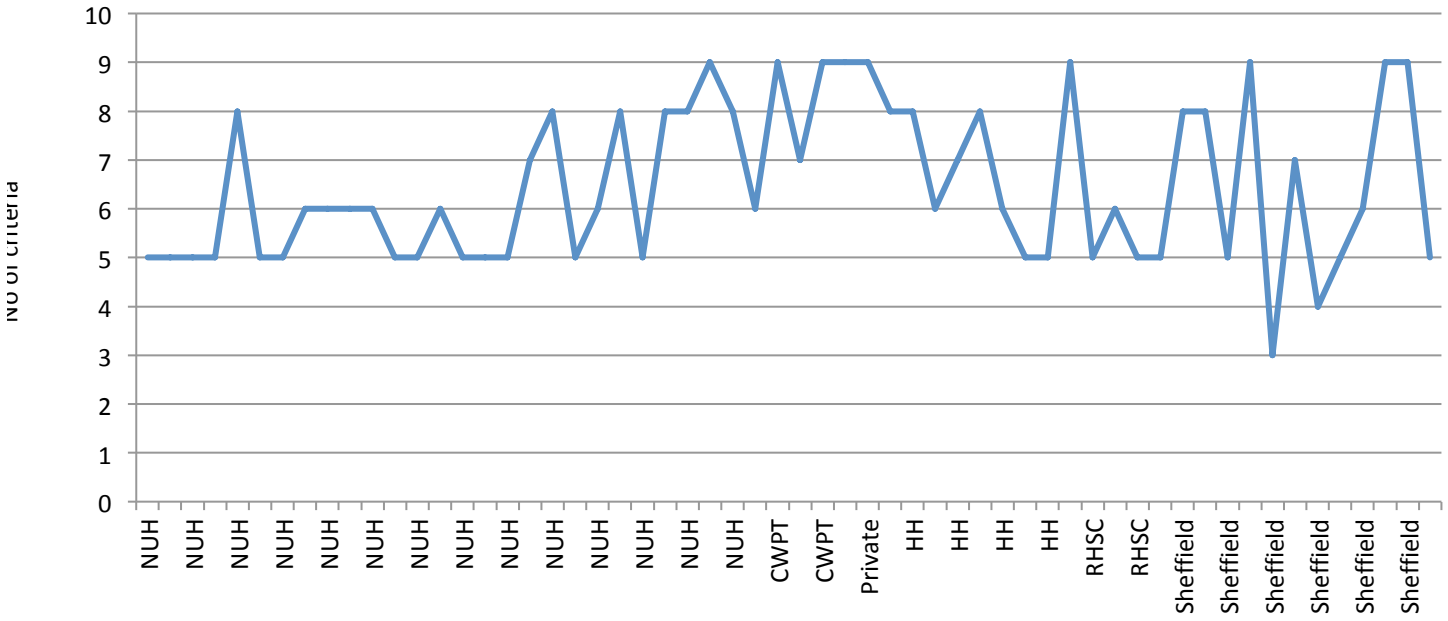
A chart to show the total number of criteria indicated for MIE in CYP in CWPT and other areas between March 2017 and May 2018.



In CWPT, there are 4 CYP who required MI-E and the total number of criteria indicated was between 6 and 9. The total number of criteria from other areas varied between 3 to 9. MI-E is a more commonly used device and data showed across the areas on average, the minimum number of criteria indicated for using MI-E was 5 or more.
If a CYP in CWPT meets 5 or more of the criteria, MI-E may be considered. This is only a guide and clinical reasoning should be applied when selecting appropriate airway clearance devices for the CYP.

NB: Sheffield criteria: The one patient with significantly lower criteria had Ataxia-telangiectasia (AT) and advised to provide MI-E from specialist centre due to a reduced PCF result (as identified in standards and see criteria above).

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