

DOCUMENT CONTROL PAGE	
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Author	Originated / Modified By: Srinivasan Palaniappan ¹ , RMCH; Kate Parkins ² , Designation: 1 Paediatric intensive care and NWTS Fellow, 2 PICM Consultant, NWTS North West (England) & North Wales Transport Service (NWTS) is the regional Paediatric Intensive Care transport service for the North West (England) & North Wales region, providing advice on patient management, in addition to clinical teams that stabilise and transport critically sick or injured children.
Ratifica-tion	1. RMCH (Host Trust): - Paediatric Medicines Management Committee (PMMC) - Paediatric Policies & Guidelines Committee 07.05.21 2. AHFT: - CDEG (Clinical Development & Evaluation Group) on: 14.01.21
Applica-tion	All Staff working throughout North West (England) & North Wales Paediatric Critical Care ODN
Circulation	Issue Date: August 2021 Circulated by: NWTS team via North West (England) & North Wales Paediatric Critical Care ODN Dissemination and Implementation: August
Review	Review Date: August 2024 Responsibility of: NWTS senior clinical team
Date placed on NWTS website: August 2021	Please enter your EqIA Registration Number here: 2021-15

1. Detail of Procedural Document.

This guideline is for staff to use when caring for any child following a drowning. It focuses on resuscitation, management, investigations and prognostics.

It is for use by staff working in the District General Hospitals of the North West and North Wales region and the NWTS team.

2. Equality Impact Assessment.

EQIA registration number RMCH: 2021-15

3. Consultation, Approval and Ratification Process

This guideline was developed with input from:

- North West and North Wales Paediatric Transport Service (NWTS) - medical & nursing
- Representatives from both Paediatric Intensive Care Units (Royal Manchester Children's Hospital and Alder Hey Children's Hospital) - medical, nursing and paediatric intensive care pharmacists
- Representatives from the North West and North Wales Paediatric Critical Care Network (PCCN) - medical, nursing and AHP (paediatrics, anaesthetics, and emergency medicine teams)

For ratification process see appendix 1.

4. Disclaimer

These clinical guidelines represent the views of the North West (England) and North Wales Paediatric Transport Service and the North West and North Wales Paediatric Critical Care Operational Delivery Network (PCCN) which were produced after careful consideration of available evidence in conjunction with clinical expertise and experience.

It is intended that trusts within the Network will adopt this guideline and educational resource after review and ratification (including equality impact assessment) through their own clinical governance structures.

The guidance does not override the individual responsibility of healthcare professionals to make decisions appropriate to the circumstances of the individual patient.

Clinical advice is always available from NWTS on a case by case basis.

Please feel free to **contact NWTS (01925 853 550)** regarding these documents if there are any queries.

Resuscitation-APLS (modify if hypothermic)
Early bystander CPR improves survival
Remove wet clothing to avoid heat loss

Manual in-line stabilisation only if concerning history (eg dive into shallow water)

Airway/Breathing

Early intubation with cuffed endotracheal tube
Lung protective ventilation strategy (ARDS)
- see page 5
CXR changes appear late

CIRCULATION

Correct relative hypovolaemia: fluid bolus 10-20ml/kg balanced crystalloid eg Plasmalyte 148 or Hartmann's solution
Inotropic/vasopressor support (to maintain MAP and CPP) - see page 6

DISABILITY

Prevention of secondary brain injury
Reduced GCS is not always due to drowning - consider other causes—see page 6

ONGOING MANAGEMENT

Discuss with NWTS early
Maintain normothermia post cardiac arrest^{1, 6}
No evidence to start routine antibiotics
Send BAL and only treat if concerns
No evidence for the use of corticosteroids

INVESTIGATIONS

Blood gas including lactate and glucose, FBC, Coag. Biochemistry + CRP, CK, LFT's & serum osmolality
Correct any electrolyte abnormalities
CK may be ↑↑ if child struggled in hypoxic conditions
Consider drug and alcohol screen
Imaging: Chest x-ray
CT Scan/MRI brain if warranted
see page 4

HYPOTHERMIA

Usually suggests prolonged cardiac arrest
Measure central temperature (rectal or oesophageal)
<30°C: Aggressive rewarming

- Max 3 shocks for shockable rhythm until temp >30°C
- Avoid adrenaline/amiodarone

30-35°C

- Resuscitation drugs: increase dose interval time to every 8 mins

see pages 6-7

RE-WARMING (TARGET 32-35°C)

Warm if core temp <30°C
IF STABLE warm at 0.5°C/ hr to 35°C:
Warm intravenous fluids (38-40°C)
Heated humidified ventilator gases
Radiant heaters/ Warming blanket

IF UNSTABLE / CARDIAC ARREST:
Aggressive rewarming
Bladder irrigation/ peritoneal lavage
Continuous hemofiltration
ECMO if available

POOR PROGNOSTIC INDICATORS

Age <3yrs	Asystole at scene
Apnoea >40 mins	Submersion >5 mins
Time to first BLS (No bystander CPR >10 mins)	

HISTORY AND ASSESSMENT

Investigate the circumstances leading to drowning

- Check for any inconsistencies in history
- Always consider safeguarding including the importance of checking that the history is compatible with developmental stage (eg domestic drowning, especially bathtub events, are associated with neglect and maltreatment)
- Any issues around safety or supervision

Consider a medical cause for drowning

- Seizures
- Arrhythmias and Long QT
- Intoxication (drug or alcohol)

Timeline – clarify and document

- Immersion time
- Time to and type of basic life support delivered
- Document if apnoea +/- asystole noted
- Time to first respiratory effort
- Time of return of spontaneous circulation (ROSC) if relevant
- Details of treatment / resuscitation required

Examination:

- Rapid primary survey including immediate management of any concerns with airway, breathing, circulation and disability (ABCD)
- Complete a secondary survey to assess for other injuries including evidence of non-accidental injury.
- Measure core temperature with an oesophageal temperature probe or rectal thermometer (preferably oesophageal if continuous monitoring required).
- Avoid hypothermia or prevent worsening hypothermia by limiting exposure.

INVESTIGATIONS

Should be guided by the child's history and clinical condition

Reduced GCS is not always secondary to drowning (especially in the absence of significant hypoxia) - exclude other causes⁸ e.g. hypothermia, traumatic brain injury, hypoglycaemia, drug or alcohol ingestion and co-existent medical condition.

- Blood gas including lactate, ionised calcium and glucose
- FBC and coagulation
- Biochemistry: U&E's, bone profile, magnesium, LFT's, C-reactive protein, Creatine Kinase and Serum osmolality
- Correct any electrolyte abnormalities found
- CK may be increased if child has struggled in hypoxic conditions. Dipstick urine (for false positive haemoglobin), and send for myoglobin (may not be available urgently)
- Consider sending drug and alcohol screen.
- Chest x-ray (Chest X-ray changes take time to appear and findings do not always correlate with clinical outcome).
- CT Scan/MRI brain if reduced GCS or concerns regarding head injury
- Blood and endotracheal aspirate culture (Fever is common during the first 24 hours but is not necessarily a sign of infection)⁵

RESUSCITATION

- Cardiac arrest APLS guidelines
- NB modify if hypothermic ie resuscitation drugs: increase dose interval time to every 8 mins
- Early and effective basic life support (BLS) reduces the mortality and morbidity. This is the most important factor for survival.
- If a defibrillator is used it is essential to dry the chest before applying the electrodes
- Record central temperature (oesophageal or rectal)²
 - <30°C: aggressively rewarm, avoid adrenaline or amiodarone (unless given via central line or intraosseous line due to reduced peripheral circulation) and maximum 3 defibrillation attempts until >30°C
 - 30-35°C: Defibrillate as usual; increase the dose interval to 8 minutes for resuscitation drugs

SYSTEMS-BASED GUIDANCE

C-SPINE STABILISATION

Injury of the cervical spine is not common in patients with submersion injuries, and is rare in children under 5 years^{2,3}

Precautions should be taken if there is any concerning history (eg dive into shallow water)

AIRWAY

- Secure airway with a cuffed endotracheal tube and consider a rapid sequence induction
See NWTS intubation guidelines (<https://www.nwts.nhs.uk/clinicalguidelines>)
- Vomiting is common after submersion episode, as the stomach may be full of swallowed water, and have an increased risk of aspiration. Therefore, intubate to protect the airway of those with reduced GCS.

BREATHING

- Aim to correct hypoxaemia using high flow humidified oxygen or NIV (CPAP) but consider early intubation and ventilation for those who fail to respond or have a low GCS or prolonged cardiac/ respiratory arrest
- Aspiration of small amounts of fluid inactivates surfactant and impairs gas exchange. Aspirated water can also cause direct lung injury resulting in ARDS.
- Respiratory deterioration can be delayed for 4–6 hours after submersion and even children who have initially apparently recovered should be observed for at least 8 hours.
- Chest X-ray changes vary from normal to localised, perihilar, or diffuse pulmonary oedema
- Bronchospasm is often seen, and most will rapidly improve with nebulised salbutamol (**see NWTS asthma guidelines**).

Lung Protective Ventilation Strategy in ARDS¹¹

- Aim adequate oxygenation: SpO₂ 92-96%
- Optimise PEEP (10-15 cm H₂O) to achieve oxygenation
- Target low tidal volumes (5-8ml/kg Ideal Body Weight if preserved compliance and 4-6ml/kg if poor compliance) if tolerated / oxygenation maintained
- Limit Plateau pressure (to ≤28 cm H₂O) if oxygenation maintained
- Permissive hypercapnoea (pH 7.15-7.30) to minimise Ventilator Induced Lung Injury (avoid hypercapnoea if traumatic or hypoxic brain injury, pulmonary hypertension or haemodynamic instability)
- Adequate sedation & neuromuscular blockade
- Consider prone positioning
- Target neutral or negative balance if haemodynamics permit

CIRCULATION

- Treat hypothermia to optimise resuscitation (see rewarming methods below)
- Pulses may be difficult to feel in hypothermic patients and cause difficulty in recognising cardiac arrest. Check ECG, ET CO₂ and arterial trace (when available). If in doubt start chest compressions.
- Insert intra-osseous access if patient is in extremis or difficulty/delay in establishing intravenous access. When more stable consider central venous and arterial access.
- Maintain age appropriate blood pressure and cerebral perfusion pressure (for those at risk of raised ICP).
- May require fluid bolus (10-20mL/kg balanced crystalloids), inotropes and/or vasopressor support **See NWTS sepsis guidelines (<https://www.nwts.nhs.uk/clinicalguidelines>)**
- If inotropic support required always deliver via intra-osseous or ideally central line to prevent potential accumulation in peripheral circulation in hypothermic patient.
- Cardiac ischaemia or arrhythmias may occur during drowning due to hypoxaemia or may have precipitated drowning event.
- Maintain or correct to normal potassium, ionised calcium and magnesium levels to stabilise myocardium. Seek advice from NWTS team.

BP Targets:

Age	Mean BP
< 1yr	45-55
1-5 yrs	70-75
6-11 yrs	75-80
12-14 yrs	85-90

NEUROLOGY

- The brain is the most vulnerable organ for asphyxia, and cerebral impairment occurs before cardiac problems in submersion.
- The treatment goal is to prevent further secondary brain injury by instigating neuroprotective measures.
- NB Reduced GCS is not always due to drowning, and it is important to exclude other causes⁸

Neuroprotective Measures

- 30 degree head up tilt
- Normoglycaemia
- 2.7% sodium chloride (3-5 mL/kg over 15-30 minutes)
- Target Na 145-150mmol/L
- Ventilate to end-tidal CO₂ 4-5kPa
- If haemodynamically stable, slow rewarm to 35°C
- Seizure control – consider load with phenytoin or levetiracetam **See NWTS status epilepticus guidelines (<https://www.nwts.nhs.uk/clinicalguidelines>)**

HYPOTHERMIA AND REWARMING

Hypothermia after drowning event is common in children due to increased surface area to volume ratio. Rapid onset hypothermia due to immersion in ICE COLD water is protective (but this is a rare event in the UK). Hypothermia slows metabolism and reduces oxygen consumption. It also reduces the inflammatory response.

However, in the UK, hypothermia in a cardiac arrest situation is usually secondary to the arrest and **not** the immersion itself.

Rewarming – Warm patients with core temperature less than 30°C (Target 32-35 °C)

Prolonged, profound hypothermia may make resuscitation and rewarming impossible.

If cardiovascularly stable aim to rewarm at 0.5°C per hr to 35°C^{2, 8}

- Warm IV fluids (38-40°C) - NB this may only have a minor effect to raise core temperature
- Heated humidified ventilator gases (42°C)
- Radiant heaters / Warming blanket

If cardiovascularly unstable, rewarm the child aggressively^{2, 8}

- Bladder irrigation with warmed saline (42°C): use 5mL/kg, instil for 1 minute, drain and repeat.
- Pleural lavage via chest drain
- Haemofiltration
- ECMO if available

ON-GOING MANAGEMENT AND SUPPORTIVE THERAPY

- Multi organ dysfunction common in paediatric drowning victims who require PICU (54%)
- Maintain normothermia following return of spontaneous circulation (ROSC) post cardiac arrest^{1,6}
- Antibiotics are **not** required routinely^{2, 5}. Gram-negative organisms, especially *Pseudomonas aeruginosa*, are common and *Aspergillus* species have been reported. If infection is suspected broad-spectrum intravenous antibiotic therapy (such as cefotaxime or ceftriaxone) should be started after blood and sputum cultures.
- No evidence for the use of corticosteroids, phenobarbitone, calcium channel blockers^{1,7}
- Inhaled nitric oxide may be indicated and may be started by NWTS team or after transfer to PICU (see NWTS or PICU guideline for use of iNO). Pulmonary bleeding is a relative contraindication^{12,14}

POOR PROGNOSTIC INDICATORS

- Duration of hypoxic-ischaemic injury (submersion > 5 minutes, no bystander CPR >10 mins and no respiratory effort > 40 mins of CPR)
- Age < 3 years
- Asystole at the scene
- Multiorgan dysfunction
- Persisting coma (GCS <5)
- Persisting acidosis (pH <7.1) and persisting hypoxia (PO₂ < 8kPa)

CONSIDER TRANSFER WHEN:

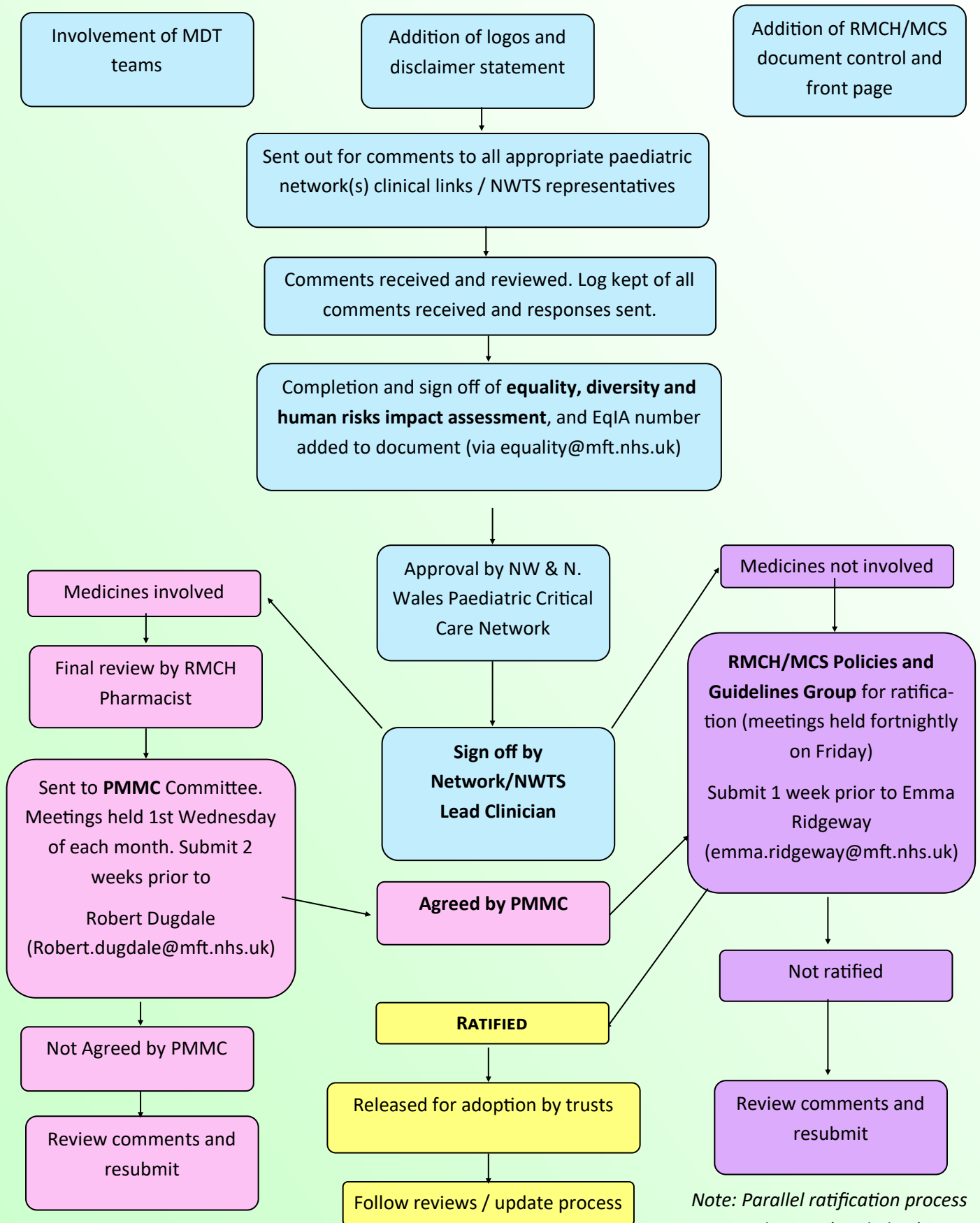
- Persisting altered level of consciousness / GCS
- Respiratory compromise requiring assisted ventilation
- Ongoing hypoxia
- Haemodynamic instability

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Appendix 1

Ratification of Guidelines with Host Organisation (MFT)

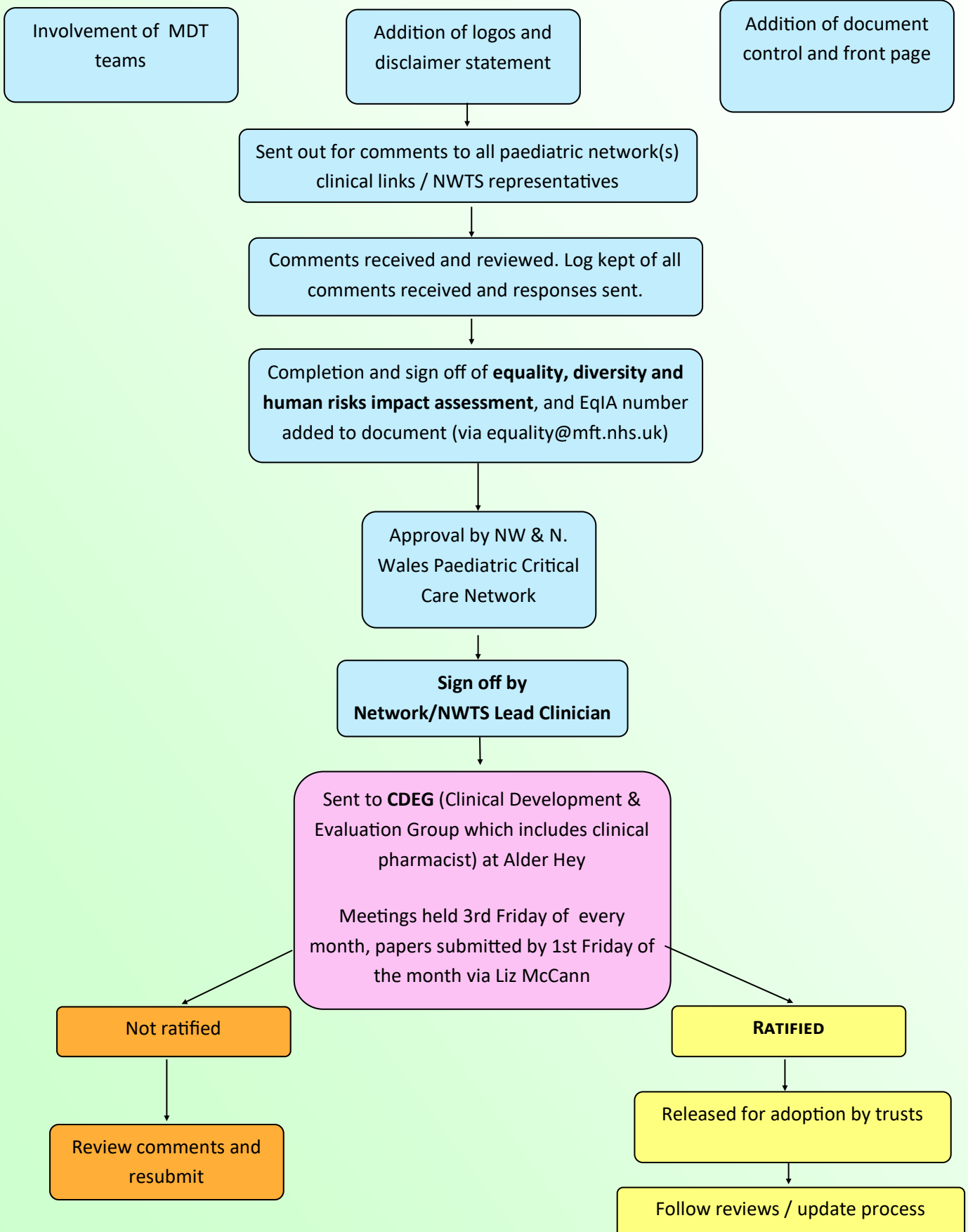


Note: Parallel ratification process with AHFT (see below)

Appendix 1



Ratification of Guidelines with Alder Hey



Resources

www.crashcall.net - for intubation drugs / sedation regime

BNFc—for drug doses

Contact numbers:

NWTS referral line: 08000 84 83 82

NWTS (North West & North Wales Paediatric Transport Service) 01925 853 550

Regional Paediatric Intensive Care Unit Alder Hey Childrens Hospital 0151 252 5241

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Next Review Due:

Guideline contact point: kate.parkins@nwts.nhs.uk or Nicola.longden@mft.nhs.uk

For the most up to date version of this guideline visit: www.nwts.nhs.uk