SUSQI PROJECT REPORT

Project Title: Daily Sedation Interruptions on Critical Care

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Background:

When patients are intubated and ventilated, they require sedation and analgesia which is administered via continuous infusion. It protects against painful and unpleasant stimuli. It augments comfort, facilitates synchronisation and tolerance of the ventilator, along with tolerance of the endotracheal tube (ETT) and invasive lines. It facilitates care and reduces the body's metabolic demand, reduces anxiety and the risk of accidental removal of lines or ETT (Sydow *et al.,* 1999). However, prolonged continuous sedation can cause excessive accumulation of medications, which may take considerable time to clear from the body and can lead to unnecessarily extended periods of intubation.

Stopping or interrupting sedation daily is beneficial in preventing this build-up. There have been many studies over the last two decades surrounding sedation and the impact of daily sedation interruptions (DSI's) in these patients. DSI refers to "the *planned, temporary cessation of continuous sedative infusions in mechanically ventilated patients,"* to allow them to awaken, unless contraindicated. It is sometimes called a **"sedation hold".**

A landmark study by Kress *et al.,* in 2000, showed a multitude of benefits associated with DSI's such as:

- A reduction in excessive sedation.
- A reduction in ventilation time.
- Reduction in length of stay (LOS).
- Reduction in sedation duration.
- Reduction in the risk of ventilated acquired pneumonia (VAP).

This prompted many more studies over the next two decades which have produced similar results, and is reflected in the Pain, Agitation, Delerium and Sleep (PADIS) guidance. This is today integrated into guidance by the Society of Critical Care Medicine (SCCM) and Guidelines for the Provision of Intensive Care Services (GPICS V2.1).

An overview of VAPs by Wagh and Acharya in 2009, noted that 86% of hospital acquired pneumonias were connected to mechanical ventilation. 10-28% of patients in critical care will develop a VAP, increasing the LOS by 28%. VAP is noted to be the most common and fatal infection within critical care. Evidence shows the cost of treating a VAP in the UK ranges from £10,000-

£20,000 per patient.

Prior to the COVID-19 pandemic, DSI's were a part of the daily bedside routine in our unit. However, due to the unprecedented long-term ventilation coupled with high oxygen and ventilatory support requirements of patients with covid, we noted that our trust moved towards deeper levels of sedation. Fewer sedation holds are completed, meaning patients are over sedated, and documentation of sedation holds, primarily documentation of failed sedation holds, is poor. Considering the vast evidence base and guidelines surrounding DSI's it became clear that improvements were needed.

In 2020 the NHS became the first healthcare system in the world to commit to becoming net zero by 2040. Currently the NHS accounts for approximately 4% of England's total emissions, with manufacturing, supply of medicines and prescribing contributing to 17% of the NHS Carbon Footprint Plus (NHS England 2025). Life cycle assessments (LCA's) are becoming more frequent within critical care units and current literature shows the carbon footprint of a critical care unit is significant with emissions ranging from 88 $kgC0_2e$/patient/day to 178 $kgC0_2e$/patient/day, some three times higher than a general ward. Pharmaceuticals have been labelled as a 'carbon hotspot' and propofol has been shown to be the second most consumed medication (Bardoult *et al.*, 2025). Improvement in DSI brings opportunity to improve patient safety and reduce environmental impact, by reducing waste of sedative medications and associated consumables, which should be a key priority in critical care.

This project was undertaken by a senior critical care staff nurse, an advanced critical care pharmacist, a critical care consultant and a critical care registrar in Northampton General Hospital (NGH). Our unit is a 16 bedded critical care unit in a district general hospital (DGH). The Intensive Care National Audit and Research Centre (ICNARC) data for NGH shows that from November 2024-2025, 730 patients were admitted to the unit, 281 of whom were ventilated. Our team embraced this project to combine a decarbonisation opportunity with best practice; optimising the delivery of sedation and daily sedation interruptions will ultimately improve patient outcomes, reducing the risk of complications associated with prolonged or excessive sedation such as VAP's.
Additionally, we are suited to tackling this challenge as we are adopting the trusts ambition for sustainability "a resilient and creative University Hospital Group, embracing every opportunity to improve care" (University Hospitals of Northamptonshire NHS Group 2021).
Our continuing project is to improve the quality and frequency of DSI's within the unit. Training and

resources aim to increase knowledge, confidence and competence of all staff whilst giving more autonomy to bed side nurses.

Specific Aims:

- To improve the number and quality of sedation holds that take place within critical care at Northampton General Hospital.
- Improve staff knowledge to ensure sedation holds take place where indicated and sedation is restarted at an appropriate rate and time.
- Reduce the amount of sedation used and reduce the length of mechanical ventilation.
- Improve documentation around sedation holds.

Methods:

Studying the system:

Current practice in performing sedation holds

Using admission and ICNARC data, a baseline population of patients admitted to critical care at NGH who were sedated and mechanically ventilated was identified, prior to the education intervention. Using the electronic patient record system (MediViewer), which scanned copies of patient admission paperwork, the hourly infusion rate of alfentanil and/or propofol, was totalled for the period of sedation and mechanical ventilation with these agents. This volume was then averaged over the total number of days for which these agents were infused, to give an average volume per day of sedation. Other sedating agents (e.g. dexmedetomidine, midazolam) were not included in the scope of this project, as their use is significantly less than alfentanil and propofol. A survey was conducted to ascertain the confidence of staff with decisions around sedation holds and how to perform these. This initial review of baseline sedation holds, along with the staff survey and anecdotal information, suggested that daily sedation holds were not being performed consistently or in line with current guidelines.

Changes made

The areas of focus for change were:

- Staff knowledge and confidence in performing sedation holds.
- Documentation currently used, including charting, informational documents and standard operating procedures (SOP's).

Staff knowledge and confidence in performing sedation holds:

Staff education, mainly focusing on critical care nursing staff, but also including medical staff, was undertaken with a presentation (Appendix 1). This outlined the current evidence and recommendations outlined by relevant bodies, including the Faculty of Intensive Care Medicine and Intensive Care Society (GPICS v2.1). The presentation given at specific educational events (e.g. nursing staff team days), was the main educational approach, however opportunistic teaching was also carried out where possible.

Documentation currently used, including charting, informational documents and SOP's:
Current critical care bedside nursing documentation is extensive, with specific sections for recording consciousness levels in the awake or sedated patient, sedation levels, and plans for sedation holds. There is also supplemental information in each bedspace with frequently used guidelines, policies and procedures (e.g. variable-rate insulin infusions). As part of this project, several documents were updated or altered. These include bedspace information: "Neurological Assessment in Critical Care" (Appendix 5), "RASS – Richmond Agitation Sedation Scale" (Appendix 3), "Critical Care Pain Observation Tool (CPOT)" (Appendix 4) and "Sedation Hold Procedure" (Appendix 2), some of which have been ratified by Critical Care Governance, and some of which are outstanding.

Bedside patient charts are undergoing updates, which are planned to include clearer guidance regarding sedation holds and accurate documentation of sedation and consciousness levels. However, this is a more extensive process and will be delayed due to lag-times related to printing and using up existing stock of bedside charts. In the interim, a sticker (Appendix 6) has been designed to go onto the existing chart regarding sedation hold decisions and results. The benefits of these changes cannot be effectively measured within the course of this project.

Changes made that didn't work

There were no noted changes that did not work as part of this project.

Main stakeholders

The main groups included in this project were staff from critical care nursing, medical and pharmacy groups, as well as sustainability experts, procurement and governance teams. Nursing staff were mainly engaged with on team educational days, medical staff at resident doctor teaching, and sustainability staff at regular meetings over Teams.

Resources required

The main resources for this project have been time to collect the above data, as well as information from procurement and manufacturers regarding costing and materials of components. No specific financial resources were used.

Measurement:

Patient outcomes:

The number of days patients receive propofol and alfentanil when DSIs are performed was modelled, along with the associated reduction in ventilated days. Reductions in sedation exposure and ventilation duration are linked to lower rates of critical care associated delirium, critical care acquired weakness, and overall length of stay. Although these outcomes cannot be directly measured using modelled data, they are routinely collected within the unit, allowing for monitoring of changes once DSIs are fully implemented. Implementing DSIs also supports closer alignment with National GPICS standards of care and enables benchmarking of our service against national expectations, which can be benchmarked in the future.

There is a potential increased risk of accidental extubation associated with reduced sedation levels. This adverse event will be monitored through Datix reporting during the next stage of the project.

Population outcomes:

- No specific negative population-level outcomes were identified.
- Potential benefit of reduction in critical care length of stay may mean more bed availability for other patients requiring critical care; however, this data is outside of the scope of this project.

Environmental sustainability:

We collected data from the NHS supply chain and ITU supplies team, to identify the average number of consumables used for sedation and ventilation from November 2024 to November 2025.

Table 1 below shows the resources which will be reduced when performing sedation holds, related to the provision of sedation and ventilation. We assumed that the following listed items would have significant reductions per 24 hours.

Table 1. List of items reduced due to sedation hold per 24 hours

	Item	No. of items per 24 hours	Projected reduction in consumables (%)
Sedation Consumables	Propofol 100ml bottle	1.71	
	Alfentanil 10ml vials	4.10	
	Filtered needles to draw up the alfentanil	0.82	
	Volumed infusion line	1	
	Syramed infusion line	1	
	50ml syringe	1	25
Ventilation Consumables	Basic Circuit suction	0.5	
	Suction tubing	0.5	33
	Heat and Moisture exchanger (HME)	2	

Consumables that lasted for one week or more (CO_2 cuvette, expiratory valve and the ventilator circuit), were excluded from the carbon footprint, as they were unlikely to alter.

A hybrid approach was used to estimate the items greenhouse gas (GHG) emissions. Both drugs were carbon footprinted based on cost using the Environmentally Extended Input Output Analysis (EEIOA). The carbon footprint of waste disposal of the propofol and alfentanil bottles/vials was based on Rizan et al.'s (2021) carbon footprint of high temperature incineration. A process-based carbon footprint analysis was carried out for a filtered needle, volumed infusion line, syramed infusion line, basic circuit suction, suction tubing, 50ml syringe and HME. The analysis included GHG emissions associated with primary materials production, transport, and disposal.

The material data for each consumable was converted into GHG emissions using carbon conversion factors from the 2025 UK Government Greenhouse Gas Conversion Factors database UK DESNZ Database. For transport emissions, where supplier address location was available, distance in miles was collected from the manufacturer location to the country-of-origin main port if imported. The distances between the port to UK main port of entry, from UK main port to the NHS supply chain distribution centre in Rugby and then to the hospital were calculated. For locally manufactured products, distance from the manufacturer to the hospital was considered. This distance was converted into emissions using carbon conversion factors from the 2025 UK Government Greenhouse Gas Conversion Factors database UK DESNZ Database. For end-of-life treatment, disposable equipment was assumed to be disposed of as clinical waste, while the packaging waste

was assumed to be dry mixed recyclable with the corresponding emission factors taken from Rizan et al.(20201).

The emissions savings were translated into equivalent miles driven in an average car with unknown fuel using a factor of 0.3399 kgCO_2e per mile, as published by the UK Government Greenhouse gas reporting: conversion factors 2025. This factor is inclusive of fuel and well-to-tank emissions.

Economic sustainability:

ICNARC data was collected regarding average length of patient sedation and ventilation, within our critical care between November 2024 to November 2025. NHS supply chain and the ITU supplies team provided data on annual propofol and alfentanil purchases for ventilated patients in critical care. They also provided the annual costs and quantities of consumables used for sedating and ventilating critical care patients. From this we were able to model reductions in consumables and drugs from implementing DSIs and model the financial reduction in avoidance of waste disposal for these items.

The financial costings per level 3 critical care bed day (which ventilated patients are categorised as) and level 2 critical care bed day (which non-ventilated patients are categorised as) were identified. The modelled reduction in length of ventilation, could then be converted into a modelled cost avoidance, from stepping down from level 3 to level 2.

Social sustainability:

Impacts on staff were explored through the pre and post education survey. It was not possible to collect patient feedback as they will be unaware of a sedation hold taking place and it is impossible to separate this aspect of care from the overall care given in Critical Care.

Results:

Due to the extensive regulatory and governance processes required within hospital settings, together with the large number of staff who would have needed training to deliver the project safely, it was not feasible to implement the project within the 10-week timeframe. We have therefore used the available literature to model expected results.

We modelled a 25% reduction in sedation medication, based on previous evidence. A systematic review by Jackson *et al* (2010), on the impact of sedation practices in critical care reviewed 7 studies which reported the impact of sedation protocols on the costs of sedative agents. Values ranged from 22% to 94% of the cost for non-protocol managed sedation. Mascia *et al* (2000), showed a total reduction in propofol costs of 52.5% when averaged across all durations of infusion. This wide variation shown in the literature is likely due to the variety of drugs used and differences in practice. Based on the evidence we modelled a cautious 25% reduction in costs.

We modelled a 33% reduction in mechanical ventilation (1.7 days) and ventilator consumables, based on the landmark study by Kress *et al* (2000). This showed that daily interruption of sedative infusions in the intervention group, was associated with a 2.4-day reduction in mechanical ventilation compared to the control group. This is a 33% reduction compared to baseline. Subsequent studies have shown less dramatic benefits; however, this is likely due to a general shift towards lighter sedation practices. As our trust has moved towards deeper levels of sedation and fewer sedation holds, we believe we will achieve a reduction of 33%.

Patient outcomes:

The 33% (1.7 days) modelled reduced duration of mechanical ventilation associated with DSIs, reduces the risk of adverse effects associated with sedation and ventilation. Adverse effects may include critical care delirium and weakness, ventilator acquired pneumonia (VAPs), increased length of mechanical ventilation and critical care length of stay (LOS). Reduction of these risks will have a positive impact upon our patients and improve outcomes. Additionally, the introduction of DSIs brings our practice in line with recommendations which has the standard that “Sedation must be individualised to patient needs and the appropriateness of a sedation hold considered daily” (GPICs V2.1). Because these critical care outcomes are influenced by numerous factors, assessing them was beyond the scope of this project.

As results were modelled, data could not be collected around accidental extubations related to DSIs. Once the DSIs are rolled out, all accidental extubations will be reviewed to determine whether they were related to DSIs and to document the outcome of each event.

Population outcomes:

A reduction in duration of mechanical ventilation can reduce the length of stay within critical care. Whilst this does not directly benefit the population, it does potentially increase the availability of

critical care beds, which can be seen as an indirect benefit. We were unable to quantify this potential outcome within this project.

Environmental sustainability:

Based on NGH ICNARC data, prior to the introduction of DSIs each ventilated patient received on average 3.2 days of sedation with propofol and alfentanil and was mechanically ventilated for 5.15 days. With 281 ventilated patients in 2024-2025, this provided an average of 899.2 days of sedation with propofol and alfentanil per year and an average of 1447 days of mechanical ventilation.

Based on a 25% reduction in propofol, alfentanil and infusion consumables and a 33% reduction in ventilator consumables, the overall carbon emissions reduced by 26.7% per episode of care. This equates to a 3.56 $kgCO_2e$ savings per episode as summarised in table 2 below.

Table 2. Carbon savings from improved DSI per patient episode

	Item	Carbon footprint per item ($kgCO_2e$)	Baseline Carbon footprint per 24 hrs/patient ($kgCO_2e$)	Baseline Carbon footprint per episode ($kgCO_2e$)	Post QI project carbon footprint per episode($kgCO_2e$)	Carbon savings per episode ($kgCO_2e$)
Sedation	Propofol 100ml bottle	0.91	1.55	4.97	3.72	2.60
Consumables	Alfentanil 10ml vials	0.33	1.35	4.33	3.25	
	Filtered needle	0.01	0.01	0.03	0.02	
	Volumed infusion line	0.17	0.17	0.54	0.40	
	Syramed infusion line	0.05	0.05	0.16	0.12	
	50ml syringe	0.12	0.12	0.39	0.29	
Ventilation	Basic Circuit suction	0.43	0.22	1.12	0.75	0.96
Consumables	Suction tubing	0.21	0.10	0.53	0.35	
	HME	0.12	0.25	1.27	0.85	
	Total	**2.35**	**3.82**	**13.32**	**9.76**	**3.56**

We extrapolated the 3.56 $kgCO_2e$ per patient saving to the annual 281 patients, with a baseline of 3.5 and 5.15 days for sedation and mechanical ventilation respectively. This resulted in total annual savings of 1001.60 $kgCO_2e$ as summarised in table 3 below.

Table 3. Annual sedation holds environmental outcomes (281 patients)

	Baseline annual Carbon footprint ($kgCO_2e$)	Post QI project annual carbon footprint ($kgCO_2e$)	Carbon savings ($kgCO_2e$)
Sedation	2925.00	2193.75	731.25
Ventilation	819.26	548.90	270.35
Total	**3744.26**	**2742.65**	**1001.60**

This is the equivalent to driving 2,947 miles in an average car, with unknown fuel, using a factor of 0.3399 $kgCO_2e$ per mile.

Economic sustainability:

The modelled 25% reduction in the use of propofol, alfentanil and the drug infusion consumables, would lead to a cost savings of £11.25 per episode as summarised in table 4. This translates to £3162.26 yearly cost saving as summarised in table 5. These are based on the cost per item and do not include provision of procurement services or associated administration time.

Table 4 sedation hold projected financial savings per episode

	Item	Cost per item (£)	Cost per 24hrs (£)	Baseline Cost per episode (£)	Post QI project cost per episode (£)	Cost savings per episode (£)	Savings by Source (£)
Sedation Consumables	Propofol 100ml bottle	3.36	5.75	18.39	13.79	4.60	**11.25**
	Alfentanil 10ml vials	1.35	5.53	17.69	13.26	4.42	
	Filtered needle	0.03	0.02	0.08	0.06	0.02	
	Volumed infusion lines	1.76	1.76	5.63	4.22	1.41	
	Syramed infusion line	0.74	0.74	2.37	1.78	0.59	
	50ml syringe	0.27	0.27	0.86	0.65	0.22	
Ventilation Consumables	Basic Circuit suction	0.44	0.22	1.13	0.77	0.36	**7.97**
	Suction tubing	5.94	2.97	15.30	10.40	4.90	
	HME	0.82	1.64	8.45	5.74	2.71	
Waste					0.13	0.09	**0.09**
	Total		**18.90**	**69.89**	**50.80**	**19.31**	**19.31**

Table 5. sedation hold projected annual financial savings

	Item	Annual Baseline cost (£)	Annual Post QI project cost (£)	Annual Post QI project financial savings (£)	Annual savings by Source (£)
Sedation Consumables	Propofol 100ml bottle	5166.44	3874.83	1291.61	3162.26
	Alfentanil 10ml vials	4969.70	3727.27	1242.42	
	Filtered needles	22.12	16.59	5.53	
	Volumed infusion lines	1582.59	1186.94	395.65	
	Syramed infusion lines	665.41	499.06	166.35	
	50ml syringe	242.78	182.09	60.70	
Ventilation Consumables	Basic Circuit suction	318.37	216.37	102.00	2239.43
	Suction tubing Suction	4298.04	2921.00	1377.04	
	HME	2373.33	1612.94	760.39	
Waste		36.49	25.73	10.76	10.76
	Sub-total	**19675.27**	**14262.82**	**5412.46**	**5412.46**
Patient cost (level 3 to level 2	£296 per day 477.6 days per year			141357.61	141357.61
Total Project Savings	**Total**			**146770.07**	**146770.07**

The modelled 33% reduction in mechanical ventilation days, reduces the average number of days ventilated from 5.15 to 3.45 (1.7-day reduction). This provides a saving of £7.97 per episode, with a projected yearly saving of £2239 from ventilator consumables as summarised in tables 4 & 5. This is based on the cost per item and does not include any staffing costs associated with the supply or usage. The combined yearly cost savings for both elements (including a small waste avoidance saving of £10.76), equates too £5412.46, with additional savings to be made around reduced procurement and staff time. This is a cost reduction based on the NHS efficiency map.

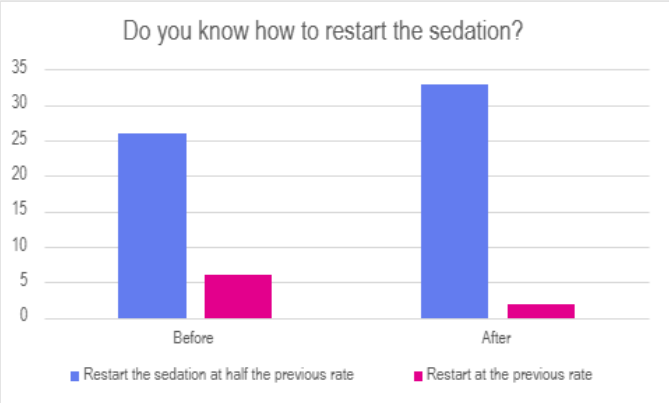
There will be a significant cost avoidance due to a reduction in VAPs. We have been unable to calculate the expected reduction due to limitations of the literature; however reduced duration of ventilation decreases the risk of a VAP. For each VAP prevented there will be a cost avoidance of £10000 to £20000 per patient, based on the reported costs of treating VAPs within the UK.

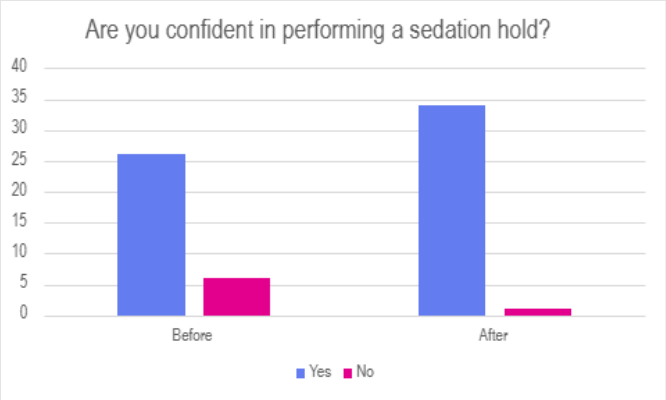
A reduced length of mechanical ventilation will likely reduce LOS on critical care. We have been unable to obtain an accurate figure from the literature to calculate a predicated reduction in LOS. The national average cost for a critical care bed is £1881 per day. Even if a patient remains on critical care once extubated, they will be able to step down from a level 3 critical care bed to a level 2 bed. Stepping patients down from a Level 3 to Level 2 generates significant financial savings due to reduced nursing ratios, lower equipment requirements and decreased resource intensity. The cost difference between Level 3 and Level 2 care for NGH is £296 per day. With a modelled reduction of 477.6 ventilator days per year, this change represents an annual saving of £141,357.61 for the Trust as demonstrated in table 5.

It is important to note that these figures do **not** translate into direct cost reductions within the Trust's budget. In practice, nurses would be redeployed to care for other patients rather than no longer being required, meaning no cashable savings would be realised. Instead, the calculation reflects the relative efficiency gained when patients require a lower level of care, rather than a reduction in actual expenditure.

Social sustainability:

Qualitative data was collected from critical care staff to assess knowledge about DSIs before and after the training session. The data showed an improvement in knowledge about DSIs and confidence in undertaking them following the training session. The percentage of staff that were confident to perform a sedation hold rose from 81% to 97% following education and the percentage of staff who knew what rate to restart the sedation at rose from 81% to 94%. The graphs below show the feedback given after the session.





The word cloud below shows an abbreviated version of the comments provided by staff upon completion of the sedation teaching session. The feedback received was positive and showed that the teaching sessions helped increase confidence and improve knowledge.

Any increase in skill level or confidence directly supports staff in performing their roles more effectively and with greater assurance. This improvement contributes to social sustainability in healthcare by promoting a more empowered, engaged and resilient workforce—key elements of a sustainable care environment. When staff feel competent and supported, job satisfaction,

retention, and team cohesion are more likely to improve, reducing turnover and the associated strain on services. In this way, enhancing staff capability through targeted education not only benefits clinical practice but also strengthens the long-term social sustainability of the critical care service.

Reducing sedation levels and shortening the duration of mechanical ventilation have the potential to create important social benefits for patients, their families, and the wider health system. Lighter sedation and earlier liberation from ventilation are associated with fewer psychological consequences of critical care, such as delirium, anxiety, or post intensive care syndrome, which can lessen the long-term burden on patients, their dependents, and follow-up services. In addition, decreasing the overall length of stay and mitigating the long-term effects of critical illness may enable patients to return to education or employment sooner, reducing loss of income and improving social stability. From a service perspective, a shorter stay for ventilated patients may ease staffing pressures and help optimise critical care capacity. -intensive-care syndrome, which can lessen the long-term burden on patients, their dependents, and follow-up services. In addition, decreasing the overall length of stay and mitigating the long-term effects of critical illness may enable patients to return to education or employment sooner, reducing loss of income and improving social stability. From a service perspective, a shorter stay for ventilated patients may ease staffing pressures and help optimise critical care capacity.

It was not possible to collect patient feedback as they are unaware of a sedation hold taking place and it is impossible to separate this aspect of care from the overall care given in critical care. Within a 10week project window, it was not feasible to measure these wider outcomes, as they typically require longer-term follow-up to capture accurately.

Discussion:

The introduction of DSIs within our critical care unit is modelled to save 1001.60 $kgCO_2e$ per year. This is the equivalent to driving 2,947 miles in an average car, with unknown fuel, using a factor of 0.3399 $kgCO_2e$ per mile. The modelled reduction in drug and consumable purchases and disposal is £5412 per year. Patients stepping down from level 3 to level care 1.7 days earlier provides an additional modelled cost avoidance of £141,358 per year. The prevention of even one VAP could add an additional cost avoidance of £10,000 - £20,000.

The reduction in sedation and mechanical ventilation is likely to improve patient outcomes by decreasing psychological complications, lowering the risk of VAPs, and potentially shortening critical care length of stay. A reduced duration of ventilation may improve population outcomes by indirectly increase the availability of critical care beds for other patient groups. Additionally, staff gaining a deeper understanding of their work, can improve social value. It can enhance their motivation, engagement, and overall job satisfaction.

The results presented are modelled on available literature and calculations using baseline data. The results demonstrate the significant benefit of improving daily DSIs. However, due to time constraints of the project we are unable to provide actual data, as this requires a longer period of roll-out to ensure adequate training and implementation before it would be appropriate to re-audit.

The baseline data used was the most recent 12 months of complete and available data for the unit; as discussed, this included 281 ventilated patients. This is, relatively speaking, a smaller proportion of patients ventilated patients compared with previous years and as such the annual cost saving could be more once the project has been fully rolled out. The exact reason why we have had fewer ventilated patients than in previous years is not fully understood and could be due to changing population susceptibility and viral strains in the years since covid.

As previously acknowledged, the primary limitation of this project lies in the literature upon which the results are modelled. The evidence base has evolved significantly over the past 25 years since the landmark study by Kress *et al.*, reflecting variations in practice across the broader critical care community. These differences are influenced by factors such as geographic location, patient demographics, and the specialisation of individual units. For example, cardiac critical care units, which frequently manage elective patients arriving ventilated, often employ sedation strategies distinct from those used in general critical care settings. Consequently, patient populations differ, leading to variations in complication rates, as evidenced by the diverse range of published data, including cost analyses. In the Kress *et al.* study, the control group exhibited a higher median duration of mechanical ventilation compared to patients at NGH—7.3 days versus 5.15 days, respectively. To address this discrepancy, reductions in ventilation duration were expressed as a percentage of the baseline total. However, it is important to note that the longer ventilation times reported in the Kress study may reflect underlying population differences.

The study by Kress *et al.* did not show a reduction in propofol use, due to the age of the trial morphine and midazolam were more common choices for sedation and so this may not be directly applicable to modern unit practices. Due to this we acknowledged and used studies by Jackson and Mascia to give our sedation reduction figures. It is our view that we currently over sedate our patients; this is evident with documented RASS scores consistently noted to be at –4 whereas current guidance would indicate a RASS score of –2 to 0 should be targeted. The implementation of DSI would help to ensure appropriate RASS scores where targeted and supports a reduction in the use of sedation.

Our critical care team is large and has varied experience, with over 100 nurses, 11 consultants and 20 resident doctors who rotate 3 to 6 monthly. Due to this teaching has been a challenge to ensure consistency with DSIs, however we have been able to facilitate teaching sessions at regular intervals and on varying platforms to cover this large group of staff. This teaching is ongoing and will become a regular feature going forward. Ensuring appropriate teaching for staff to enable the project to be launched is not feasible within the 10-week project timeframe.

Once an appropriate cohort of staff have completed the training to allow implementation, the DSI stickers will be rolled out to be used alongside the 24-hour chart. This will support DSI and in future the stickers will be integrated into the 24-hour chart. With appropriate training, supporting information within the bedspaces and reinforcement of the contraindications for sedation holds, this will reduce the risk of patients being under sedated or inadvertent self extubation.
DSIs have the potential to reduce complications associated with sedation and oversedation, including the need for tracheostomy during prolonged weaning, VAP's and extended rehabilitation requirements. A reduction in LOS in critical care and the avoidance of these complications can facilitate earlier hospital discharge. Cost savings are realised across multiple areas, not only in drug, ventilator, and consumable use, but also through reduced complication management and resource utilisation. It is important to note that predicting the duration of mechanical ventilation or identifying patients who will develop ventilation-related complications remains challenging. Similarly, among patients extubated earlier, it is impossible to determine retrospectively who would have experienced complications without intervention.

While this project does not aim to calculate formal annual cost avoidance, literature provides a range of costs associated with each complication. For example, treating a single case of VAP is estimated to cost between £10,000 and £20,000. Based on current evidence and discussion within

the results, we anticipate savings in nursing time, VAP-related costs, and ventilated bed occupancy; however, these elements cannot be quantified over a yearly period within the scope of this study. Rehabilitation-related costs are also difficult to measure, as they extend beyond critical care into ward-based recovery.

Whilst this project will reduce the amount of propofol per patient, we acknowledge that there will still be an element of wastage as the unit currently uses 100ml bottles so any residual propofol will need to be discarded after 24 hours. Alfentanil is in 10ml vials which allows nurses to draw up smaller infusions for lower infusion rates to avoid wastage. This highlights an area for further savings and waste reduction by considering the use of 50ml bottle of propofol if sedation is running at a lower rate and wastage is likely.

Conclusions:

Evidence from the last 25 years since the landmark study by Kress, has demonstrated multiple benefits to critically unwell patients when DSIs are performed effectively. Recent evidence has also demonstrated the environmental benefits of DSIs through reduction of carbon emissions through reduced drug usage, consumables and waste products. This project, although not rolled out in the 10-week time frame has used established evidence, baseline departmental data and the NHS national 5-year plan to demonstrate cost and environmental benefits of DSIs in this critical care. The results from this project show a significant impact both financially and in terms of CO_2e emissions despite the conservative estimates and calculations described.

DSI teaching is being integrated into established teaching and meeting opportunities across the MDT so that all staff members are reached with regular training, updates and optimised standards of DSIs, so both patients and environmental benefits can be achieved. To ensure standardised practiced and sustainable improvement in DSIs, modifications in the current 24-hour patient charts will be made to integrate the sticker into the permanent layout of the 24-hour chart.

The utilisation of staff surveys before and after teaching, show the benefit of training through marked improvement in knowledge, staff satisfaction and confidence. These surveys will continue to be used to ensure engagement with the project and effectiveness of the teaching with the potential to highlight areas for further development.

Teamwork, communication, varied experience and skill set was key to the success of this project. The team members were from a cross-sector of the MDT, each of whom brought different skills which were critical to the success. Engagement with the wider team through teaching is also key as this will ensure an effective future launch.

Following the successful implementation of all project phases and the establishment of consistent, effective DSIs within our unit, a re-audit will be conducted after one year to evaluate improvements, monitor progress, and identify further opportunities for development to ensure optimal patient care. Providing staff with feedback on the financial and environmental benefits of DSIs, such as reduced sedation use and support for earlier extubation, is expected to serve as a strong motivator for sustaining best practice. The initiative will continue to be supported by the wider critical care team, and following the one-year re-audit, appropriate forums for disseminating the results will be considered.

The success of comprehensive data collection has been driven by the commitment and determination of the project's lead authors: Laura Robinson, Faye Ranger, and Dr. Charlotte Hall, whose exceptional efforts have been instrumental in bringing this work to fruition.

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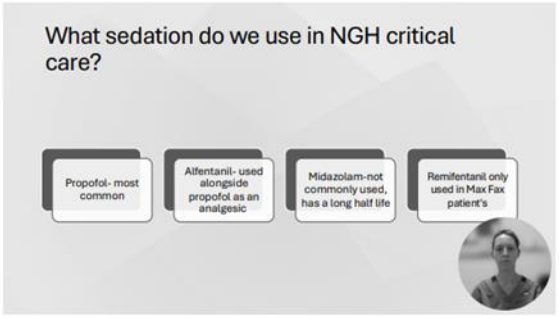
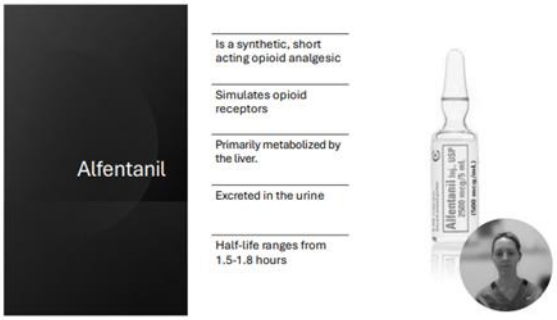
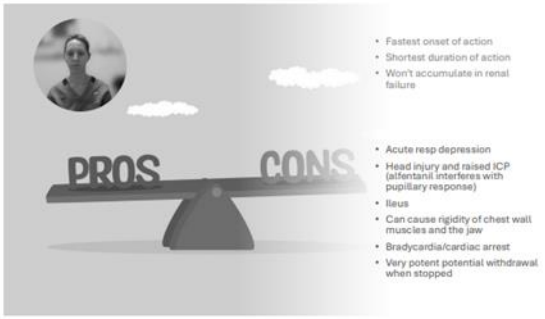
Appendices

Appendix 1: DSI teaching presentation







- Came into medical use in 1982, approved for the induction of anaesthesia and sedation
- Short acting benzodiazepine CNS depressant
- Increase the action of GABA receptors producing a sedative effect, relaxing skeletal muscles, inducing sleep, anaesthesia and amnesia
- Half life of approx 3 hours
- Metabolised in liver, excreted by the kidneys

- Rapid onset of action
- Faster recovery than other benzodiazepines
- Does not cause cardiovascular side effects
- Useful in patients who are withdrawing from alcohol/drugs or difficult to sedate
- Acute resp depression
- Recovery can be longer in the elderly or repeated doses
- In conjunction with other sedatives can cause increased sedation
- Accumulates in adipose tissue prolonging sedation in obese, renal or hepatic impaired pts
- Half life increases the longer it is given
- No longer recommended by PADIS

Unlike any other sedative we use in the unit due to its unique nature.

Profound analgesic property

Selective mu-opioid receptor agonist

Onset time 1.5 minutes

Half-life 3-5 minutes

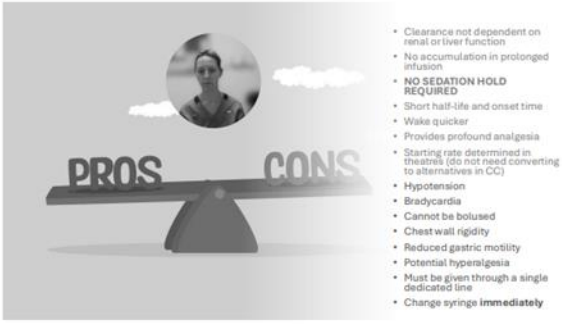
Metabolised by tissue esterases and thus does not accumulate in renal or hepatic dysfunction or prolonged infusion time.

DO NOT PERFORM SEDATION HOLD

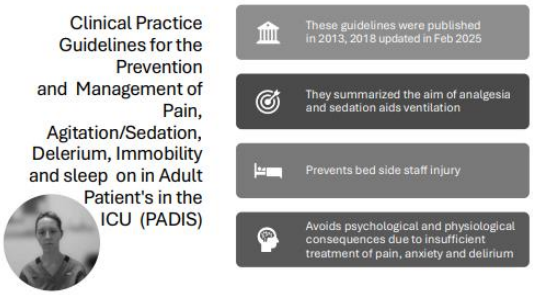
Prepare and administer alternative analgesia prior to stopping

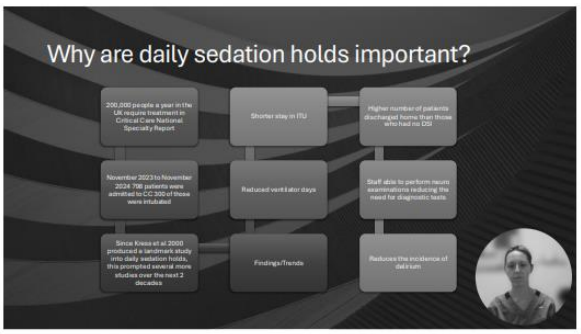
Significance of sedation is changed to provide adequate analgesia and tolerance of procedures and invasive lines rather than inducing unconsciousness

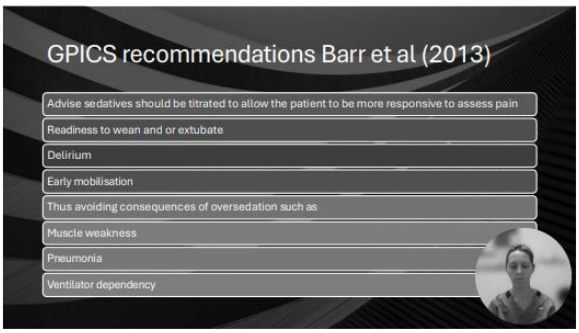
Please refer to separate Remifentanil guidelines

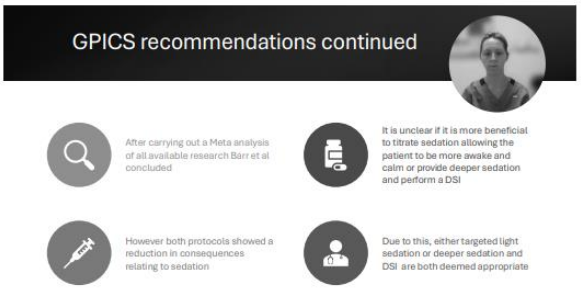


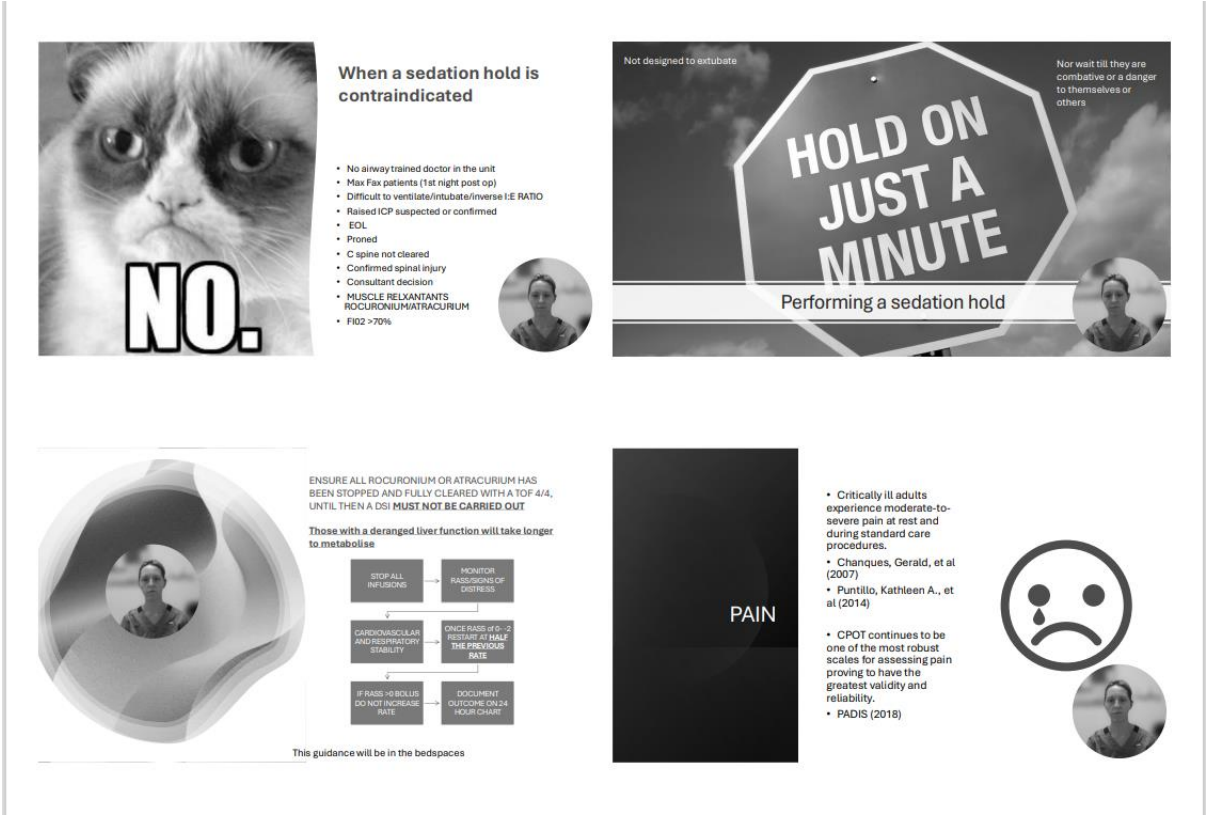
- Clearance not dependent on renal or liver function
- No accumulation in prolonged infusion
- **NO SEDATION HOLD REQUIRED**
- Short half-life and onset time
- Wake quicker
- Provides profound analgesia
- Starting rate determined in theatres (do not need converting to alternatives in CC)
- Hypotension
- Bradycardia
- Cannot be bolused
- Chest wall rigidity
- Reduced gastric motility
- Potential hyperalgesia
- Must be given through a single dedicated line
- Change syringe **immediately**

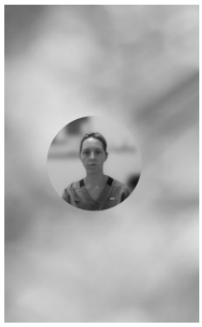








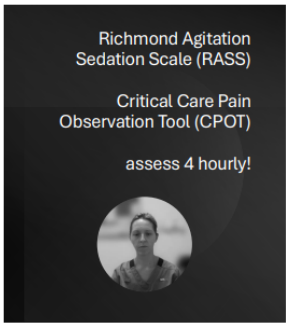


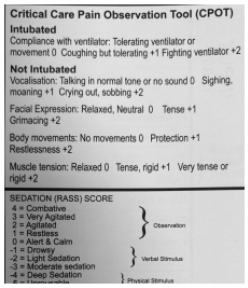


AGITATION

"Sedatives are frequently administered to critically ill patients to relieve anxiety, reduce the stress of being mechanically ventilated, and prevent agitation-related harm" Barr et al (2013)

"If a sedative is needed, the patient's current sedation status should be assessed and then frequently reassessed using valid and reliable scales" PADIS (2018).





To restart or not to restart that is the question?

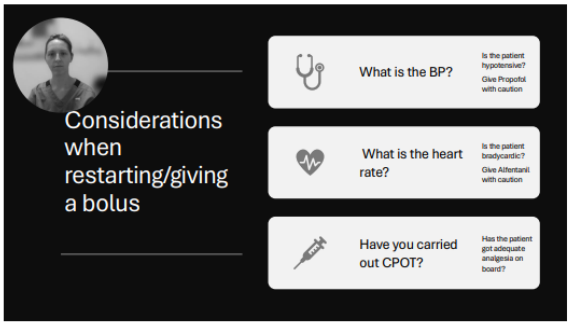
We don't always wake to extubate

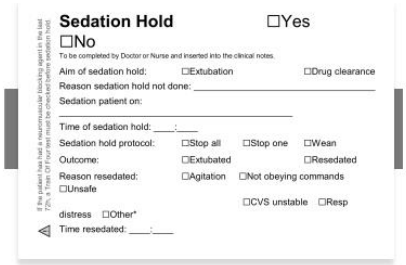
Plasma sedation levels climb

Patients become 'over sedated'

A DSI allows these levels to return to a more normal level

Can wake more quickly and come off the vent

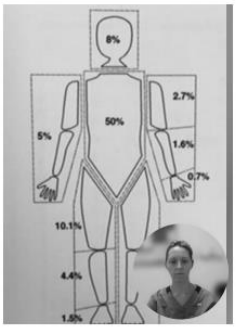


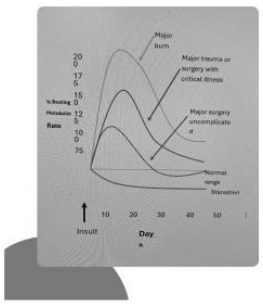


Documentation on the 24 hour chart

Why are DSI's so important for nutrition?

- Rapid depletion of lean body mass
- Especially skeletal muscle
- Regardless of nutritional support (Hart et al.2002, Redi et al 2004)
- In stressed and septic pts up to 16% loss of total body protein
- In only 21 days
- 67% is from muscle (Monk et al.1996)

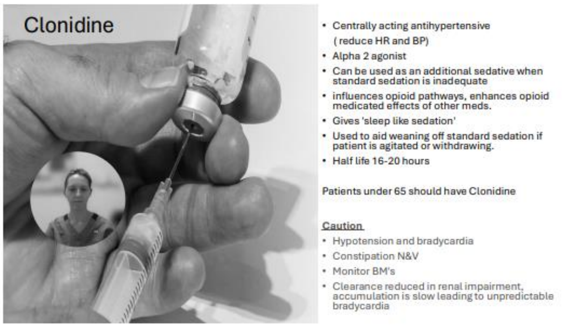


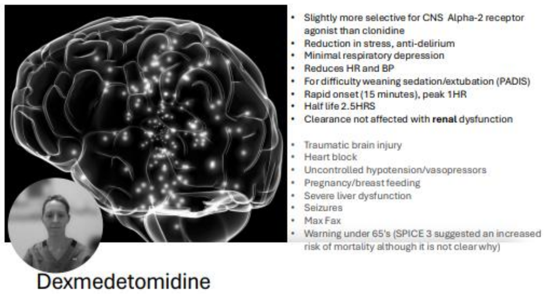


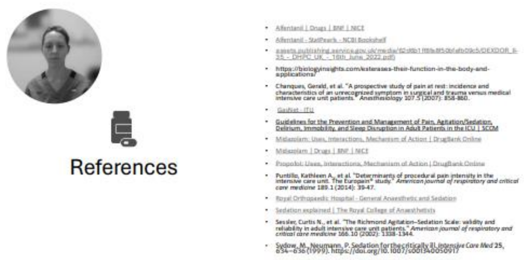
- Duration of increased requirements
- Increase rapidly in 1st 48hrs
- Remain elevated for weeks
- Even after discharge

Propofol = empty calories

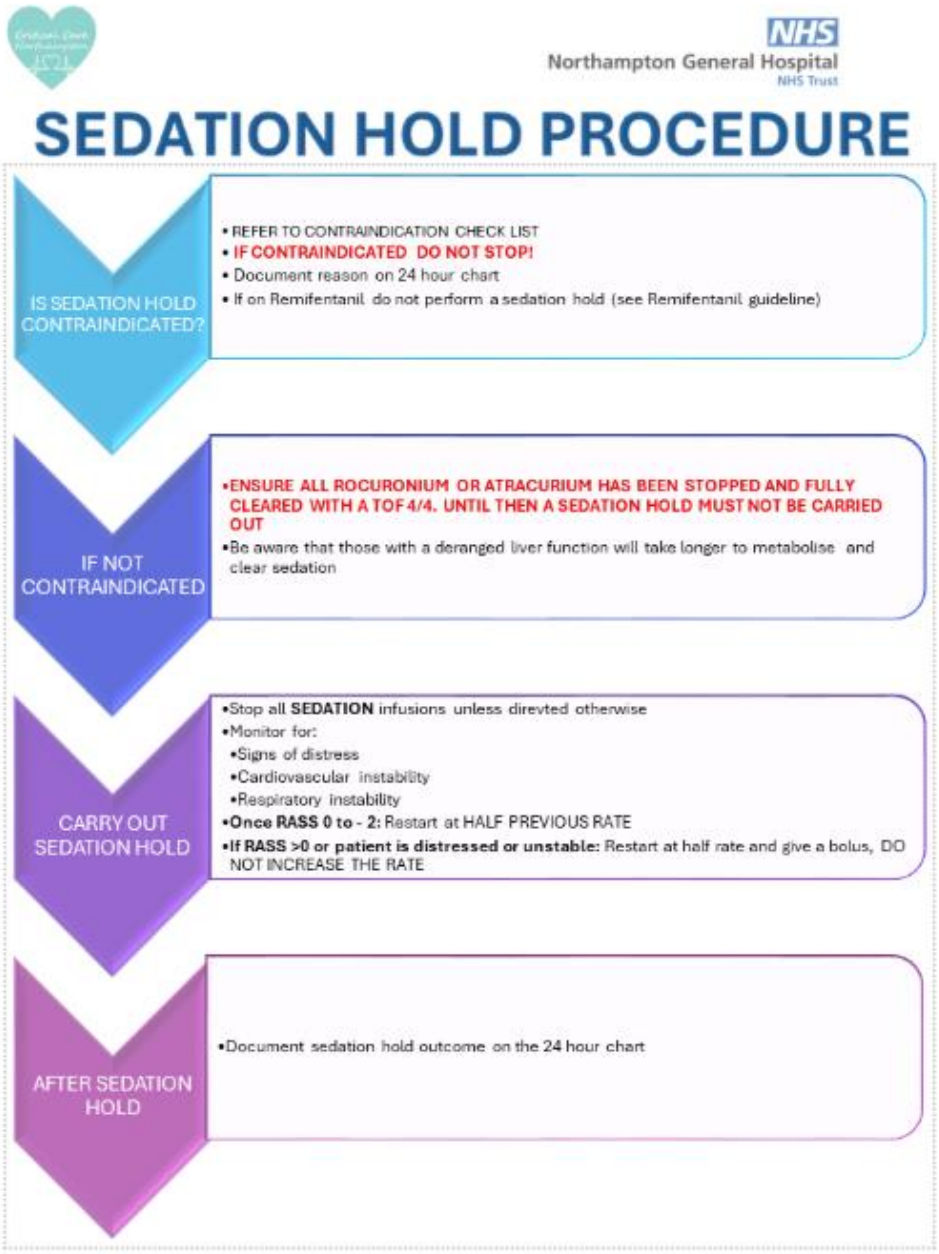
- Rates change rapidly
- Propofol is a high energy
- Fat based 1.1 kcals/ml
- 10mls hr x24 hrs = 264kcals
- 20mls hr x 24 hrs = 528kcals
- 25 mls hr x 24 hrs = 660kcals
- Meaning we can over or underfeed patients
- Leads to acute complications







Appendix 2: Sedation hold bedspace information



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SEDATION HOLD PROCEDURE

IS SEDATION HOLD CONTRAINDICATED?

- REFER TO CONTRAINDICATION CHECK LIST
- **IF CONTRAINDICATED DO NOT STOP!**
- Document reason on 24 hour chart
- If on Remifentanil do not perform a sedation hold (see Remifentanil guideline)

IF NOT CONTRAINDICATED

- **ENSURE ALL ROCURONIUM OR ATRACURIUM HAS BEEN STOPPED AND FULLY CLEARED WITH A TOF 4/4. UNTIL THEN A SEDATION HOLD MUST NOT BE CARRIED OUT**
- Be aware that those with a deranged liver function will take longer to metabolise and clear sedation

CARRY OUT SEDATION HOLD

- Stop all **SEDATION** infusions unless directed otherwise
- Monitor for:
  - Signs of distress
  - Cardiovascular instability
  - Respiratory instability
- **Once RASS 0 to - 2:** Restart at HALF PREVIOUS RATE
- **If RASS >0 or patient is distressed or unstable:** Restart at half rate and give a bolus, DO NOT INCREASE THE RATE

AFTER SEDATION HOLD

- Document sedation hold outcome on the 24 hour chart

Author: Faye Ranger, Dr Matthew Beadle, Laura Robinson
Ratified by Critical Care Governance October 2025
Review date October 2028

sedation hold document for bedspaces.docx

Appendix 3: RASS score bedspace information

Rass scoring 1.docx

Northampton General Hospital NHS Trust

RASS - Richmond Agitation Sedation scale

Observe the patient assess and treat pain FIRST

Rass score should be 0- - 2 unless stated otherwise by doctors

Score	Term	Description	Adjustment
+4	Combative	Combative, violent, danger to staff	Bolus 2ml sedative agent every 2 minutes until a score +1 achieved. Increase rate of infusion by 2ml/hr
+3	Very agitated	Pulls or removes tubes, aggressive behaviour	As above
+2	Agitated	Frequent, non-purposeful movement or ventilator desynchrony	Bolus 1ml sedative agent every 2 minutes until a score +1 achieved. Increase infusion by 1ml/hr
+1	Restless	Anxious, movements not aggressive	Increase infusion by 1ml/hr
0	Alert and calm		Maintain sedative infusion at current rate for a maximum of 6 hours. After 6 hours, reduce Infusion rate by 1 ml/hr
-1	Drowsy	Not fully alert, >10 secs awake, eye contact to voice	As above
-2	Light sedation	Less than 10 secs awake, eye contact to voice	Reduce sedation rate by 1ml/hr
-3	Moderate sedation	Any movement, no eye contact to voice	As above
-4	Deep sedation	No response to voice, movement to physical stimuli	Hold infusion unless contraindicated e.g. paralysed, proned, head injury, terminal care
-5	Unrousable	No response to voice OR physical stimuli	As above

Adapted from Sessler et al 2022
Author Faye Ranger, Dr Matthew Beadle, Laura Robinson
Ratified by Critical Care Governance October 2025
Review date October 2028

Appendix 4: CPOT bedspace information

Critical Care Pain Observation Tool (CPOT)

NHS Northampton General Hospital NHS Trust

If your patient is alert and orientated, please refer to the trust Patient Pain Assessment Tool (Adult)

Intubated		
Component	**Description**	**Score**
Ventilator	Tolerating	0
	Coughing and tolerating	+1
	Fighting ventilator	+2
Facial expression	Relaxed, neutral	0
	Tense	+1
	Grimacing	+2
Body movements	No movements	0
	Protection	+1
	Restlessness	+2
Muscle tension	Relaxed	0
	Tense, rigid	+1
	Very tense, very rigid	+2

Not intubated (not able to communicate i.e low GCS)		
Component	**Description**	**Score**
Vocalisation	Talking in normal sound or tone	0
	Sighing, moaning	+1
	Crying out, sobbing	+2
Facial expression	Relaxed, natural	0
	Tense	+1
	Grimacing	+2
Body movements	No movements	0
	Protection	+1
	Restlessness	+2
Muscle tension	Relaxed	0
	Tense, rigid	+1
	Very tense, very rigid	+2

Always optimise non-drug measures
Repositioning
Relief of gastric distension if appropriate
Reassurance
Relief of urinary distension if appropriate

Response to pain score	
Score 0 = No pain	Repeat CPOT after 4 hours or if new signs develop
Score 1 = Mild pain	Review analgesia, adjust as appropriate, repeat CPOT after 4 hours or sooner if new signs develop
Score 2 = Moderate pain	Consider bolus analgesia +/- increasing regular analgesia, repeat CPOT in 30 minutes
Score 3+ = Severe pain	Seek medical review, give bolus analgesia

Adapted from guidance by Dr Malanjum and Dr Outram
Author Faye Ranger, Dr Matthew Beadle, Laura Robinson
Ratified by Critical Care Governance October 2025
Review date October 2028

Critical Care Pain Observation Tool (CPOT).docx

Appendix 5: Neurological assessment in Critical Care

Northampton General Hospital NHS Trust

Neurological Assessment in Critical Care

Glasgow coma scale INTUBATED PATIENT		
BEHAVIOUR	**RESPONSE**	**SCORE**
EYES OPEN	**Spontaneously**	**4**
	To verbal command	**3**
	To pain	**2**
	No response	**1**
BEST MOTOR RESPONSE	**Obeys commands**	**6**
	Localises to pain	**5**
	Withdraws to pain	**4**
	Flexion abnormal	**3**
	Extensor response	**2**
	No response	**1**
BEST VERBAL RESPONSE Endotracheal tube	**Appears orientated, able to converse *facial smile, orientated to sound***	**5**
	Responsive but ability to converse questionable	**3**
	Generally unresponsive	**1**

Glasgow Coma Scale NON-INTUBATED PATIENT		
BEHAVIOUR	RESPONSE	SCORE
EYES OPEN	Spontaneously	4
	To speech	3
	To pain	2
	No response	1
BEST MOTOR RESPONSE	Obeys commands	6
	Localises to pain	5
	Withdraws to pain	4
	Flexion abnormal	3
	Extensor response	2
	No response	1
BEST VERBAL RESPONSE	Orientated to time, place and person	5
	Confused	4
	Inappropriate words	3

Adapted by Faye Ranger, Dr Matthew Beadle and Laura Robinson
Ratified by Critical Care Governance.....
Review date.....

Appendix 6: DSI sticker

If the patient has had a neuromuscular blocking agent in the last 72h, a Train Of Four test must be checked before sedation hold.

Sedation Hold ☐Yes ☐No

To be completed by Doctor or Nurse and inserted into the clinical notes.

Aim of sedation hold: ☐Extubation ☐Drug clearance

Reason sedation hold not done: _____

Sedation patient on:

_____

Time of sedation hold: ____:____

Sedation hold protocol: ☐Stop all ☐Stop one ☐Wean

Outcome: ☐Extubated ☐Resedated

Reason resedated: ☐Agitation ☐Not obeying commands ☐Unsafe ☐CVS unstable ☐Resp distress ☐Other*

Time resedated: ____:____

Critical success factors

Please select one or two of the below factors that you believe were most essential to ensure the success of your project changes.

People	Process	Resources	Context
☐ Patient involvement and/or appropriate information for patients - to raise awareness and understanding of intervention ✓ **Staff engagement** ☐ MDT / Cross-department communication ☐ Skills and capability of staff ☐ Team/service agreement that there is a problem and changes are suitable to trial (Knowledge and understanding of the issue) ☐ Support from senior organisational or system leaders	**✓clear guidance / evidence / policy to support the intervention.** ☐ Incentivisation of the strategy – e.g., QOF in general practice ☐ systematic and coordinated approach ☐ clear, measurable targets ☐ long-term strategy for sustaining and embedding change developed in planning phase ☐ integrating the intervention into the natural workflow, team functions, technology systems, and incentive structures of the team/service/organisation	☐ Dedicated time ☐ QI training / information resources and organisation process / support ☐ Infrastructure capable of providing teams with information, data and equipment needed ☐ Research / evidence of change successfully implemented elsewhere ☐ Financial investment	☐ aims aligned with wider service, organisational or system goals. **✓Links to patient benefits / clinical outcomes** ☐ Links to staff benefits ☐ 'Permission' given through the organisational context, capacity and positive change culture.

This template is adapted from SQUIRE 2.0 reporting guidelines.

Template References

- SQUIRE | SQUIRE 2.0 Guidelines (squire-statement.org)
- Home | Sustainable Quality Improvement (susqi.org)