Conscious sedation service for geriatric and special-care dentistry: A health policy brief

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Abstract

Background: Geriatric and special care dentistry (GSD) involves oral health care for seniors and individuals with disabilities. Due to ethical issues, finances, waiting times, treatment versatility and so on, conscious sedation (CS) may have a place to optimise the delivery of care.

Objectives: This article identifies considerations for implementing CS in GSD services in Singapore.

Methods: Taking the form of a health policy brief, this review (a) defines the situation for patients with special-care needs and justified the need for dental CS, (b) makes reference to practices from countries with established dental CS services, (c) states and evaluates available CS techniques for the GSD centre in Singapore and (d) discusses action plans and considerations for implementation.

Results: Demographic analysis revealed that 23.8% of the GSD patients could have benefitted from CS, or 44.7% of all patients who required behavioural management. The key advantages of CS included enhanced safety, more teeth saved and a reduction in general anaesthesia wait, amongst others. Conventional dental CS techniques included midazolam via various routes, nitrous oxide and ketamine. To establish a CS service, key points of consideration need to be conceptualised first, such as adequate training, perception of patients and providers, operational costs, facilities and developing guidance specific for oral health professionals.

Conclusion: A local CS service will be beneficial for GSD patients in view of the challenges faced. A group of experts and stakeholders is needed to provide practical consensus.

Keywords

Conscious sedation, special-care dentistry, moderate sedation, disability medicine, Singapore

Introduction

The field of geriatric and special-care dentistry (GSD) are linked due to the similar barriers that they face, and they are tackled by the Ministry of Health Singapore as a single public-health predicament. This cohort will be collectively referred to as patients with special-care needs (PSCN).

A woman with severe intellectual disability presented at the GSD centre due to a painful lower right molar. A simple extraction was required. Being unsuitable for treatment under local anaesthesia (LA) due to challenging behaviours, the individual and family were presented with the option of dental treatment under general anaesthesia (GA). For a single tooth removal, dental treatment under GA is often not advised. Even with GA, many concerns arise, such as conservation of other decayed teeth, sustainable follow-ups, ward availability and waiting times.¹ Within the hospital policy, legal representatives are required for consent involving adults lacking mental capacity.² The application for court-appointed deputyship can take three to six months and costs between S$3000 and S$10,000.³ Due to unfamiliarity with the hospital environment, this woman previously had a difficult experience in the induction room and on the wards. Therefore, her family preferred chair-side management after weighing the

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risks and benefits. After three acclimatisation visits, extraction was attempted with physical restraint. However, the procedure had to be aborted due to profound difficulties faced. Such difficulties are commonly faced by dental PSCN. This experience also highlighted obstacles faced by the patient’s family, the dentist and the medical team.

**Aims and objectives**

This review is in the form of a health policy brief that identifies key considerations for implementing conscious sedation (CS) in GSD services for Singapore. A health policy brief consists of four steps: define the problem, make the case, state the policy and discuss the impact.

**Defining the problem**

**Background**

The Ministry defines CS as ‘... a drug induced depression of consciousness during which patients respond purposefully to verbal commands, either alone or accompanied by light tactile simulation. No interventions are required to maintain a patent airway and spontaneous ventilation is adequate. Cardiovascular function is usually maintained.’

Due to high-profile cases of mismanaged sedation in the 1980s and 1990s, the administration of CS (or moderate sedation) by dentists internationally further declined. CS is only briefly covered in lectures in the local dental undergraduate curriculum. The need for CS for GSD

In the past few decades, regulatory changes internationally refined the scope of dental sedation (disallowing anaesthesia), improved training outcomes and mandated emergency preparedness, raising safety in CS practice. A large-scale UK audit of 1756 CS cases in 2016 reported minor complication rates of 2.3%. These complications, such as desaturation, paradoxical reaction, tolerance, bradycardia or tachycardia, were defined as ‘no harm’ or ‘low harm.’ In terms of efficacy, CS has been shown to improve patient experience and chair-side cooperation, control gag reflex and enhance long-term attendance. As a result, there has been a growing international enthusiasm to revise CS use in dentistry.

**Table 1**. Comparison of case-mix complexity and demographic profile of PSCN versus those requiring behavioural management.

| Ability to communicate | 2.95/8 | 5.06/8 |
|------------------------|--------|--------|
| Ability to cooperate   | 3.09/12| 5.64/12|
| Medical status         | 6.09/12| 4.16/12|
| Oral risk factor       | 6.61/12| 6.99/12|
| Access to oral care    | 2.00/8 | 2.75/8 |
| Legal and ethical barriers | 1.93/8 | 3.32/8 |
| Total banded score     | 22.7   | 27.9   |

| Demographic profile |
|---------------------|
| Patients, n (%)     | 160 (100%) | 85 (53.1%) |
| Average age, years (median) | 50.2 (54) | 39.8 (29) |
| 25th–75th percentile of age (range) | 28.3–68 (11–94) | 23–61 (11–94) |
| Percentage ⩾65 years old | 31.3% | 21.2% |
| Male:female ratio    | 1:0.975 | 1:0.889 |

Data from a special-care dentist’s log in the GSD centre, where 160 PSCN were seen over 49 sessions in 2017. Patients not fulfilling the criteria of PSCN were not recorded.

PSCN: patients with special-care needs; GSD: geriatric and special needs/care dentistry.

As a tertiary centre, Singapore’s only GSD centre sees PSCN who are medically complex and find more difficulty cooperating. The PSCN who require behavioural management are treated either under LA or under GA. The collated data of PSCN seen by a special-care dentist in 2017 revealed that 53.1% required varying levels of behavioural management (Table 1). The majority included younger individuals with learning disabilities (65.7%) and seniors with acquired cognitive disorders (18.8%). Of 85 PSCN requiring behavioural management, 41.2% coped well with behavioural techniques, including tell-show-do, graded exposure, distraction techniques and light clinical holding. A fifth (21.2%) had dental treatment completed with significant difficulties, notably physical restraint, and would have been better managed with CS if it had been available, and 23.5% were unable to complete their dental treatment without any pharmacological management (CS or GA included). The remaining 14.1% presented extremely challenging behaviours and required dental GA rather than CS.
This analysis illustrated that 23.8% of all PSCN, or 44.7% of PSCN requiring behavioural management, could be presented with the option of CS. In reality, PSCN who do not qualify for GA and cannot cope with behavioural techniques were treated with significant physical restraint or placed on active surveillance (i.e. watchful waiting).

The importance of upholding human rights is outlined in the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD) and Association of Southeast Asian Nations (ASEAN) Disability Forum. Indeed, the ‘least restrictive option’ in the ‘best interests’ of PSCN should be employed, according to the statutory principles of the Mental Capacity Act. Since extensive physical restraint has its risks (Table 2) and is often argued to be counterproductive, some PSCN are therefore placed on active surveillance, subjecting them to the chronic effects of untreated oral diseases.

With modern techniques, the risk of morbidity in GA is low, and postoperative morbidity is reportedly similar between dental patients with and without disabilities. However, GA as the only option for pharmacological restraint consists of practical difficulties and demands thorough individual assessments. One major consideration for dentistry under GA is that treatment planning undergoes a fundamental shift from a conservative to an invasive one. A service evaluation concluded that if inhalation sedation (IHS) was used, children could save 1.34 teeth for every GA session avoided. Also, GA provides limited preventive dentistry.

On the operational aspect, various studies have concluded that CS can be more cost-effective than GA. These studies are, however, limited due to difficulty in conducting randomised trials ethically. Also, those that have been conducted were based on a paediatric population. No similar studies for PSCN were found.

A summary of practical concerns regarding dental GA in the GSD centre is outlined in Table 4, where the introduction of a CS service could create more options to overcome these barriers.

**Table 2. Summary of points for the risk of excessive physical restraint**

| Risks involved in physical restrain | Examples |
|-----------------------------------|----------|
| Physical trauma                   | • Osteoporosis increasing risk of fracture  
|                                   | • Collagen defect and tendency for dislocation  
|                                   | • Hand pieces can lacerate tissues during aberrant movements  
|                                   | • Sharps injury or needle breakage  |
| Risk of anxiety-related emergencies | • Angina and acute coronary syndromes  
|                                   | • Adrenal crisis with hypothalamic–pituitary–adrenal axis suppression  
|                                   | • Asthma attack  
|                                   | • Seizures  
|                                   | • Stroke, especially in patients with high blood pressure  |
| Hazard to health-care staff       | • Biting the clinicians’ hands  
|                                   | • Blunt injuries due to challenging behaviour; in stronger adults  |
| Difficulty to execute competent dentistry | • Inability to use hand-pieces  
|                                   | • Poor moisture control  
|                                   | • Limitations in choice of treatment  |
| Unpredictability in outcome       | • Dependent on patient’s cooperation on the day  |
| Psychological trauma              | • Traumatic experience causes long-term aversion to dental environment  
|                                   | • Loss of trust to people involved in physical restraint  |
| Contrary to respect of human rights | • UN Convention on Rights of Persons with Disabilities  
|                                   | • ASEAN Disability Forum  
|                                   | • Human Rights 1998: Article 5 No torture, inhuman or degrading treatment (European Convention on Human Rights)  |

**Table 3. Cost-effectiveness comparison of CS versus GA**

| Study            | Comparison                                      | Cost-analysis parameter                                      | Conclusion                                                                 |
|------------------|------------------------------------------------|-------------------------------------------------------------|---------------------------------------------------------------------------|
| Lee et al. 2001  | Dental GA versus oral sedation in children      | Using treatment and societal costs to evaluate dental relative-based value units | If more than three sessions of CS was required for same ‘units’ of treatment, GA may provide more cost savings |
| Lyratzopoulos and Blain 2003 | Inhalation sedation with nitrous oxide versus GA in children | Staffing costs | Inhalation sedation estimated to cost one-third that of outpatient GA |
| Jameson et al. 2007 | Hospital-based dental GA versus primary-care advanced CS in children | Fees, costs and treatment pathways used to calculate ‘average cost per child treated’ | GA was 46.6% more expensive than advanced CS |

CS: conscious sedation; GA: general anaesthesia.

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**Make the case**

**Singaporean guidelines and hospital policies**

Within the Ministry of Health and Singapore General Hospital databases, three guidelines and three policies relevant to CS in...
Comparing Singapore and international practices

The Singapore guidelines and policies were compared to international publications of CS practice (Table 6). Areas of comparison include the level of statement, targeted audience, specifications or restrictions in techniques and various operational differences. These are incorporated into the detailed discussion of proposed CS techniques below (some details have been left out for brevity).

State policy

List of available techniques for GSD centre

With an understanding of the patient demographics (Table 1), an evaluation of the guidelines and policies (as above), an
understanding of the established international practices of CS and discussion with the Head of Department and Clinical Head at the GSD centre, the following CS techniques were selected for literature review and proposal: regimen in intravenous (i.v.) midazolam administration, nitrous-oxide inhalation, oral and intra-nasal midazolam, combination of nitrous oxide with oral or intra-nasal midazolam, and ketamine.

**Regimen in i.v. midazolam administration**

Administration of i.v. midazolam is widely practised internationally with very different dosing regimens across different medical specialties. As a result, many medical guidelines and policies seldom specify dosing regimens to provide flexibility on indication. From the documents, a dosing regimen was specified in the Singapore General Hospital policy and South African Society of Anaesthesiologists guidelines. They were compared to other regimens recommended in Craig and Boyle, the National Institute for Health and Care Excellence (NICE) and Medscape (Table 7).  

The South African regimen has a maximum recommended midazolam dose of 3 mg, making it less feasible for use as a single agent in dentistry. The regimens of NICE and Medscape are similar, with little variability compared to the regimen proposed in Craig and Boyle. The Singapore General Hospital's regimen, with an intermission of five minutes between increments, is suited for medical uses, that is, premedication for GA, anaesthesia in long-term care facilities or as an adjunct in multi-drug sedation. Titrating midazolam alone at this speed may not be effective in reaching therapeutic sedation for dental procedures. In adults, where distribution half-life is 6–15 minutes, redistribution of midazolam from the GABA receptor sites will occur before clinical sedation can occur, particularly at higher doses (Table 7). For example, it will take 17 minutes to administer only 5 mg. In addition, the slower administration would require an overall higher dose to reach comparable therapeutic depth. The cumulative dose is increased, resulting in prolonged recovery, side effects and more profound respiratory depression. While the longer intermission appears to provide a safety net against over-sedating, by considering the indications, ease of comprehension instructions, nitrous oxide’s safety often contrasts with its classical vasodilative, anxiolytic and analgesic properties. It is suggested that nitrous oxide can reduce the need for GA and the number of teeth extracted. While its success in dentistry reportedly exceeds 90%, there is a need to re-evaluate for PSCN or seniors aged >65 years.

Another review describes its use in the elderly with dementia for anxiety and involuntary movements, recommending a 50% premixed gas, no more than 30 minutes of usage and at least three minutes of 100% oxygen recovery. For the elderly, adequate IHS can be achieved with as little as 25% because of age-related changes in lung gaseous exchange and the sensitivity of neuronal receptors. Craig and Boyle recommends titration to response to avoid dose-related side effects. The benefits and contraindications for PSCN are summarised in Table 8.

**Nitrous oxide in dentistry for PSCN**

IHS with nitrous oxide is safe, as it is inhaled and exhaled unchanged, minimally metabolised by the body. Nitrous oxide antagonises the presynaptic N-methyl D-aspartate receptors in the central nervous system. It is also postulated to work on the β-subunit of the nicotinic acetylcholine receptors and 5-HT3 receptors, and possibly mimics nitric oxide to confer its classical vasodilative, anxiolytic and analgesic properties.

IHS is regarded as the first-choice sedation for children and those with early dementia, obesity or haemoglobinopathies. It is suggested that nitrous oxide can reduce the need for GA and the number of teeth extracted. While its success in dentistry reportedly exceeds 90%, there is a need to re-evaluate for PSCN or seniors aged >65 years.

For 2 mg, they take 12, 10 and 8.5 minutes, respectively. Indeed, seniors may sometimes require as little as 2 mg i.v. midazolam, which may provide adequate sedation for more than 30 minutes.

Practising i.v. midazolam within medical clinics (outside public hospitals) is not restricted by this policy. Instead, the Ministry’s guidelines are followed. However, ASA III patients should only be sedated in secondary or tertiary institutions. Other considerations for sedationists include advanced life-support training, fasting parameters and monitoring vital signs every five minutes. A clinical and haemodynamic monitoring frequency of five minutes is also recommended in the ASA Task Force Guidelines, ‘unless such monitoring interferes with the procedure’. Other guidelines broadly specify to monitor ‘continuously’, ‘intermittently’ or ‘throughout the procedure’.

Few studies to date have established which regimen is most suitable for dental CS. However, titrating to response is highly recommended to confer safety. The regimen for i.v. midazolam required by the GSD centre would be more feasible for seniors requiring doses around 2 mg. Other techniques have to be considered to meet the needs of other PSCN.

**Oral and intra-nasal midazolam**

Both oral and intra-nasal administration of benzodiazepines are indicated for individuals who are not amenable to IHS or
Table 7. Comparison of administration of midazolam for conscious sedation.11,16,41,44

| Adults | Loading | Titration | Time to reach a dose of |
|--------|---------|-----------|-------------------------|
|        |         |           | 5 mg                    |
|         |         |           | 10 mg                   |
| Singapore General Hospital policy | 0.5–2 mg over 2 minutes | 1 mg/5 minutes to effect | 17 minutes |
| South African guideline | 0.05–0.1 mg/kg (maximum 2 mg) every 10 minutes or when maximum recommended dose of 3 mg is reached | 1 mg/30 seconds to effect | 3.5 minutes |
| Craig and Boyle | 2 mg over 30 seconds, wait 90 seconds | 1 mg/30 seconds to effect | 17 minutes |
| N.A. | Maximum recommended dose is 3 mg | 1 mg over 30 seconds, wait 4 minutes | 4 minutes |
| Craig and Boyle | 2 mg over 30 seconds, wait 90 seconds | 1 mg/30 seconds to effect | 3.5 minutes |
| N.I.C.E | 2–2.5 mg at a rate of 2 mg/minute | Add 1 mg slowly to effect | At least 3.5 minutes |
| Medscape | 0.5–1 mg (maximum 2.5 mg) over 2 minutes | Repeat dose every 2–3 minutes to effect | At least 6 minutes |

| Elderly | Loading | Titration | Time to reach a dose of |
|---------|---------|-----------|-------------------------|
|        |         |           | 2 mg                    |
|         |         |           | 5 mg                    |
| Singapore General Hospital policy | 0.5–1 mg over 2 minutes | 0.5 mg/5 minutes to effect | 12 minutes |
| South African guideline | N.A. Maximum recommended dose is 3 mg | Not specified | 10 minutes |
| Craig and Boyle | 1 mg over 30 seconds, wait 4 minutes | 0.5 mg/2 minutes to effect | 8.5 minutes |
| Craig and Boyle | 0.5–1 mg at a rate of 2 mg/minute | Add 0.5–1 mg slowly to effect | 20.5 minutes |
| N.A. | Maximum dose 7.5 mg | Add 0.5–1 mg slowly to effect | 20.5 minutes |
| Craig and Boyle | 1 mg over 30 seconds, wait 4 minutes | 0.5–1 mg at a rate of 2 mg/minute | 20.5 minutes |
| N.A. | Maximum recommended dose 3.5 mg | Repeat 1 mg every 2–3 minutes to effect | 20.5 minutes |
i.v. procedures due to intellectual disabilities, needle phobia, claustrophobia and so on.\textsuperscript{11,29,30} These two techniques are non-titratable, and a bolus dose (even if weight is used) is an estimate of optimal dose. Attempts to titrate oral doses may augment respiratory depression and extend recovery.\textsuperscript{11} A comparison of midazolam’s actions via various routes are presented in Table 9.

In ageing individuals, pharmacokinetic changes elevate susceptibility to benzodiazepines. Early studies of midazolam suggested that the oral bioavailability of midazolam is 20% higher in seniors (aged >74 years) than in adults.\textsuperscript{56} First-pass metabolism correspondingly reduces by 1% every year after the age of 40 years.\textsuperscript{60} In addition, liver function reduces by 30–40% with age, particularly in cytochrome P450 3A4 complex.\textsuperscript{59} This retards benzodiazepine’s metabolism and excretion time, increasing the circulatory and distribution time within the body. For example, the elimination half-life of diazepam is regarded as 43–72 hours. In the elderly, this can extend up to 96 hours.\textsuperscript{56} Overall, these changes hasten onset and lengthen recovery time for oral midazolam.

Pharmacodynamic changes in the elderly are also known to occur. Indeed, the National Patient Safety Agency Rapid Response Report called for a review of elderly benzodiazepine dosing. Yet, the scientific evidence regarding its exact cause is inconclusive.\textsuperscript{45,47} Biochemical studies suggest changes in GABA\(_A\) receptor subunit composition.\textsuperscript{68} For example, subunit \(\alpha 3\) is up-regulated, while \(\alpha 2\) and \(\alpha 5\) are down-regulated, altering their neurological effects.\textsuperscript{68}

Oral sedation is intended to sedate, dissimilar to premedication doses aimed for anxiolysis. This can be prepared by

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Table 8. Summary of benefits and contraindications of nitrous oxide in dentistry for PSCN.\textsuperscript{11,29,34,48–67}

| Benefits | Contraindications |
|----------|-------------------|
| Sickle-cell anaemia | • Low oxygen tension or acidosis as a result of anxiety or respiratory depression or anxiety can precipitate a sickling crisis |
| Morbid obesity | • IHS is more ideal than i.v. sedation\textsuperscript{31} |
| Elderly | • Most sedatives mask arousal mechanisms and reduce respiratory effort and pharyngeal muscular tone\textsuperscript{49,56} |
| Chronic pulmonary disease | • Sleep apnoea was found to reduce oxyhaemoglobin saturation by 4%\textsuperscript{56} |
| Liver and kidney impairment | • Adiposity increases benzodiazepine distribution up to 2.8×, prolonging recovery\textsuperscript{58} |
| Disability | • IHS is best avoided if there is recent ocular or cranial surgeries.\textsuperscript{11} |
| Care-resistant behaviours | • Sleep apnoea was found to reduce oxyhaemoglobin saturation by 4%\textsuperscript{56} |

IHS: inhalation sedation; i.v.: intravenous.
adding the i.v. formulation to a sweet drink to mask its bitterness. Otherwise, a syrup formulation such as AmSed® is acceptable to most children and individuals with intellectual disabilities, especially when well fasted (Table 9).11

For intra-nasal sedation, the nasal Mucosal Atomiser Device™ atomises the solution into a fine mist of 30–100 µ.69 Transmucosal membrane absorption of midazolam into the nasal capillary (Kisselbach’s plexus) circumnavigates the first pass and theoretically enters the brain within a few seconds.69 The resultant bioavailability is thus around 80%.40 As midazolam has a pH of 3.5, this produces a stinging sensation on contact with the nasal mucosa. Lidocaine (20 mg/mL) may be added to this formula.11

The instructions on oral and intra-nasal (or transmucosal) sedation do not differ much from i.v. routes because they can all result in a similar depth of sedation. Establishing venous access is recommended for safety.11,13,17,18 Monitoring instruction includes pre- and postoperative blood pressure, mandatory peroperative pulse oximetry and continuous clinical monitoring of vital signs.11,18

In Singapore under the Ministry’s and hospital’s instructions, the requirement for venous access is not specified for oral or intra-nasal sedation.5,41 To achieve sedation at the ‘moderate’ level, intra-operative monitoring is compulsory.41 No other specific instructions are outlined except for paediatric sedation.5 Considering the limitations in the available regimen for administering i.v. sedation (Table 7), these two non-titratable methods have become comparatively important.

**Combination of nitrous oxide with bolus midazolam via oral or intra-nasal routes**

The combination technique of IHS and bolus midazolam was proposed, as there were concerns regarding the appropriateness of cannulating a patient in the dental surgery. Additionally, some PSCN may not accept venous access well.

Whilst this combination is occasionally used for children, very few studies, if any, were carried out in adult dental patients, much less PSCN. A 2010 guideline by the National Clinical Guideline Centre and commissioned by NICE provides a systematic review-like analysis of the available randomised controlled trials for this combination technique in children and young adults.50 The summary of the trials demonstrates equivalent safety in the combination compared to a single midazolam intra-nasal or oral dose (Table 10). There is also expectedly a longer induction and recovery in the oral IHS combination compared to intra-nasal IHS.50

| Onset   | Duration of action | Bioavailability | Dose                        | α-T-1/2 | β-T-1/2 |
|---------|-------------------|-----------------|-----------------------------|---------|---------|
| i.v.    | 3–4 minutes       | 20–60 minutes   | 100%                        | 1       | 0.5     |
| Intra-nasal | 5–10 minutes   | 20–60 minutes   | 70–90%                      | 1       | 0.5     |
| Oral    | 10–20 minutes     | 60 minutes      | 41–50%                      | 1       | 0.5     |

1Dose dependent.
2Dose adjusted accordingly for children and the elderly.

The Standards by Alberta Dental Association and College in Canada specifically acknowledge the combined use of a single oral sedative (benzodiazepines or antihistamines) with nitrous oxide and oxygen.14 There are four ‘modalities of sedation’, each with increasing difficulty and hence with corresponding logistical, personnel and training requirements. Combination techniques are modality 3, positioned between ‘oral administration of a single dose of a single sedative drug’ (modality 2) and ‘parenteral and parenteral-like sedation’ (modality 4).14 Fasting to standards are expected, but no dosing regimen is specified. The Standards outline that dentists using modality 3 should be at least trained in utilising ‘supplementary’ sedatives, and those who qualify to administer modality 4 sedation and GA are automatically permitted to perform this.14 This suggests that i.v. sedation under modality 4 may be viewed as more complex, requiring a higher level of training than the oral IHS combination.

While combined IHS and bolus midazolam theoretically provides a deeper level of sedation than either single drug methods, it is yet to be determined if the midazolam/nitrous oxide combination is more effective in improving cooperation in PSCN. Analysing lower-quality clinical studies for combination techniques in PSCN provides another perspective (Table 11). A clinical trial by Collado et al.76 reported that people with intellectual disabilities accept non-cannulation modules better and were 6.5 times more ‘disturbed by cannulation’ than cannulation. The results of these studies should be analysed with caution due to considerable heterogeneity.76–79

A systematic review of nitrous oxide with i.v. midazolam use in dentistry did not report significantly improved efficacy either.80 Nonetheless, the studies suggest that these combination techniques possess a good safety profile, similar to either drugs administered alone.76–79 In the case of PSCN and the elderly, no single route is strictly better than another. A repertoire should be available to individualise treatment accordingly. With adequate staff training, emergency preparedness and audit of service, this technique can be proposed.

**Ketamine sedation**

Ketamine is a N-methyl D-aspartate glutamate receptor antagonist with various complex neurological effects postulated. It is a versatile sedative and analgesic that can be administered via oral, intramuscular, intra-nasal or i.v. routes.16 While ketamine is widely tested in paediatrics, its use in the GSD field is less researched.81–84 A literature search specifying ‘adults’, ‘disability’, ‘dentistry’ and ‘ketamine’ revealed few studies, including a non-randomised double-blinded trial and three case reports (Table 12).
Oral ketamine remains a popular choice for patients with learning disabilities, and treatment can indeed be successfully rendered in almost all cases. Recovery from oral administration, however, can take four to six hours, and recovery facilities suitable for this length of stay are required. In addition, ketamine produces a state of dissociative consciousness separate from the spectrum known for other sedatives such as nitrous oxide, benzodiazepines or propofol. This 'trance-like cataleptic state', though not exactly loss of consciousness, can cause difficulties in assessing sedation level.

### Table 10. RCTs of nitrous oxide and oral/intra-nasal midazolam combination from NCGC guidelines

| RCTs       | Intervention                          | Comparison                          | Summary of findings (quality of evidence) |
|------------|---------------------------------------|-------------------------------------|------------------------------------------|
| Fuks 1994  | Intra-nasal 0.3 mg/kg +N2O 50%        | Intra-nasal 0.2 mg/kg + N2O 50%     | • All patients completed procedure (moderate) |
|            | + Papoose Board®                      | + Papoose Board®                     | • No vomiting reported (moderate)        |
| Fukuta 1994| Intra-nasal 0.3 mg/kg +N2O            | Intra-nasal 0.2 mg/kg + N2O         | • No reported events of assisted respiration or vomiting (moderate) |
|            |                                       |                                     | • No significant differences in completion, duration, desaturation, vomiting (low to very low) |
| Hartgraves 1994 | Oral 0.5 mg/kg +N2O 40–45% | Intra-nasal 0.2 mg/kg + N2O 40–45% | • No significant difference in completion or oxygen desaturation (low to very low) |
| Lee-Kim 2004 | Oral 0.7 mg/kg +N2O 40–45% | Intra-nasal 0.3 mg/kg + N2O 40–45% | • Significantly longer induction time (3×) for oral group (moderate) |
|            |                                       |                                     | • Significantly longer working time (+10 minutes; low) |
| Luhman 2001 | Oral 0.5 mg/kg +N2O 50%              | Oral placebo + N2O 50%              | • All procedure completed (moderate)        |
|            |                                       |                                     | • No events of aspiration and respiratory interventions (moderate) |
| Al-Zahrani 2009 | Oral 0.6 mg/kg +N2O 30–50% | Oral 0.6 mg/kg + N2O 30–50% | • No significant difference in vomiting (low) |
|            |                                       |                                     | • All procedures completed (low)            |
|            |                                       |                                     | • No significant differences in induction time and duration of procedure (low to very low) |

RCT: randomised controlled trial.

### Table 11. Summary of non-RCTs with inhalation sedation and oral/intra-nasal midazolam

| Non-RCTs              | Intervention                          | Comparison                           | Summary of findings |
|-----------------------|---------------------------------------|--------------------------------------|---------------------|
| Fuks 1993 Uncontrolled trial | Intra-nasal 0.2 mg/kg +N2O titrated   | No control group                     | Good/effective behaviour shown in: |
| 4–21 years old Combative and mentally handicapped |                                       |                                     | • 69.2% of patients receiving infiltration |
|                       |                                       |                                     | • 93.8% receiving rubber dam |
|                       |                                       |                                     | • 76.2% having cavity prep done       |
|                       |                                       |                                     | • 84.2% having restoration placed     |
|                       |                                       |                                     | • 87.5% having pulpotomy done         |
| Wood 2010 Audit 3–13 years old | Intra-nasal midazolam +N2O titrated | No control group                     | • 96% patients referred for dental GA accepted treatment under this technique |
|                       |                                       |                                     | • 93% of parents found this acceptable|
|                       |                                       |                                     | • 50% of children found intra-nasal acceptable |
|                       |                                       |                                     | • No clinically relevant oxygen desaturation |
| Collado 2013 Non-RCT 7–66 years old Intellectual disability group | i.v. midazolam with: 50% N2O or oral or rectal midazolam 0.3–0.5 mg/kg or nil | No control group | 25.4% of the ID versus 3.9% DA group were ‘disturbed by cannulation’ |
|                       | Dental anxiety group | i.v. midazolam with: 50% N2O or oral or rectal midazolam 0.3–0.5 mg/kg or nil |                                      |
|                       |                                       |                                     | 58.9% of ID versus 90.3% DA were ‘relaxed after induction’ |
|                       |                                       |                                     | 31% ID versus 3% DA had ‘oral or rectal midazolam’ |
|                       |                                       |                                     | The above differences were found to be significant |
|                       |                                       |                                     | Significant difference in average onset (oral: 20.1 minutes vs. intra-nasal: 12.1 minutes) |
|                       |                                       |                                     | Significant difference in difference in (recovery) alertness between groups (higher for intra-nasal) |
| Musani 2015 Crossover trial 4–10 years old | Oral 0.2 mg/kg +N2O | Intra-nasal 0.1 mg/kg + N2O | For i.v. midazolam, the patients required for cannulation nitrous oxide or oral/rectal premedication or no additional preparations. |

ID: intellectual disability; DA: dental anxiety.
Ketamine’s non-specific inhibition of catecholamine uptake might induce sympathomimetic effect, and may cause significant ischaemia in cardiac disorders. The manufacturer’s instructions also discourage ketamine use in adults aged >40 years and in patients with coronary artery disease. At the level of CS, however, low bolus doses (Table 12) are said to be safe, with preservation of protective reflexes and spontaneous ventilation and no induction of sympathetic effects of heart rate and blood pressure. Chudrofsky et al. also demonstrated the possibility of using ketamine (with midazolam) safely for adults up to the age of 68 years. As for patients with developmental disorders, such as Down’s syndrome carrying a one-third risk for cardiac anomalies, excluding underlying cardiac defects remains the crux. Therefore, specific training is required to assess, monitor and address complications such as laryngospasm, hallucinations or emesis.

Both the Ministry’s guidelines and the hospital’s policy do not specify ketamine use, although there is still a need for assessment, monitoring, and recovery pursuant to instructions. The operator and sedationist should be separate individuals, although the administration and monitoring can be undertaken by a trained and dedicated member of staff such as an enrolled or registered nurse. Ketamine is a procedural sedative, is already widely used in Singapore for dental-related procedures in children. In a review of 500 emergency cases in Singapore, as much as 54.4% of all i.v. and intramuscular ketamine sedation was used for paediatric laceration repairs, mostly in the oral facial region. Despite longer recovery and infrequent side effects, ketamine’s sedation profile is unique, which can be invaluable for achieving cooperation in PSCN. This CS technique has the potential to be further explored in the GSD centre.

### Discuss impact

The provision of CS service in a GSD centre is about safely optimising the patient's treatment options in view of the barriers currently faced. At this point, the safety perceptions of CS amongst local dentists can be actively improved through education. Comprehensive training for CS in dentistry is not yet available locally, and this is critical to ensure the safety and efficacy of the techniques. This sentiment is also reflected by special needs dental specialists in Malaysia. This paper highlighted the possibility of using nitrous oxide and oral or intra-nasal midazolam either separately or as a combination, using i.v. midazolam and also using ketamine for PSCN. There is a wider range of techniques, such as dexmedetomidine, which has been gaining popularity in dentistry. Practical considerations of the centre's set-up may still dictate the choice of technique to be accepted. These can include: emergency preparedness, including advanced life-support training and facility set-up; specific training for dental dentists and supporting staff; acceptability of CS by the institution's authorities and anaesthetists; acceptability of CS by patients and families; ethical consideration and consent processes; and spatial requirements (e.g. floor plan for recovery, wheelchair, etc.).

### Table 12. Summary of studies of ketamine’s use for adults with disabilities in dentistry

| Study       | Patient group                           | Treatment rendered                        | Summary of findings                                      |
|-------------|-----------------------------------------|-------------------------------------------|----------------------------------------------------------|
| Green 1999  | 17 ‘mentally disabled’ adults            | Sedation: Ketamine i.m. (2.9–4.7 mg/kg) or i.v. (1.0 mg/kg) | All procedures competed                                   |
|             | 17–49 years old                         | **Treatment:** Laceration repair (10) Exodontia (1) Pelvic examination and dislocation (6) | Median time from induction to discharge: 130 minutes (range: 50–260 minutes)  |
| Petros 1991 | 4 ‘mentally retarded and extremely difficult’ adults | Sedation: Ketamine oral 500–700 mg with sweet drink | Treatment started in 30–60 minutes                          |
|             | 16–38 years old                         | **Treatment:** Dental exam, LA, amalgam fillings, scale or polish | Postop to discharge: 4–6 hours                            |
| Rosenberg 1991 | 1 ‘extremely combative’ and strong (96 kg) | Sedation: Ketamine oral 700 mg (6–8 mg/kg) | Oral dose provided: 8–10 mg/kg                           |
|             | 16 years old                            | **Treatment:** Dental exam, x-rays, pelvic exam | Sedated ‘deeply’ within 15 minutes                        |
| Horacek 2012 | 29 ‘intellectually disabled’ patients | Sedation: Either: Oral ketamine (5 mg/kg) + clonidine (2 μg/kg) + midazolam (0.3 mg/kg) or Oral ketamine (5 mg/kg) + midazolam (0.3 mg/kg) | No significant differences for onset (all within 25 minutes) |
|             | Average age 36 years                    | **Treatment:** Pelvic examination and dislocation (6) | No significant differences in ‘interaction scale’ and ‘calmness score’ |
|             | Double-blinded trial                   | Exodontia (1)                              | All procedures completed                                  |
|             |                                        | Laceration repair (10)                     | Median time from induction to discharge: 130 minutes (range: 50–260 minutes)  |
|             |                                        | Pelvic examination and dislocation (6)     | Side effects: emesis, airway repositioning, seizures/myoclonus |
|             |                                        | **Treatment:** Dental exam, LA, amalgam fillings, scale or polish | No reported hallucinations                              |
|             |                                        | Exodontia (1)                              | Atropine (anti-sialogue) and midazolam provided          |
|             |                                        | Pelvic examination and dislocation (6)     | Treatment started in 30–60 minutes                          |
|             |                                        | **Treatment:** Dental exam, x-rays, pelvic exam | Postop to discharge: 4–6 hours                            |
|             |                                        | Exodontia (1)                              | Oral dose provided: 8–10 mg/kg                           |

No significant differences in ‘interaction scale’ and ‘calmness score’
Conclusion
Taking the form of a health policy brief, this review (a) defined the situation for PSCN and justified the need for dental CS, (b) made reference to practices from countries with established dental CS services, (c) stated and evaluated available CS techniques for the GSD centre in Singapore and (d) discussed action plans and considerations for implementation.

Pursuant to article 25 in UNCRPD to which Singapore is committed, ‘persons with disabilities have the right to the enjoyment of the highest attainable standard of health without discrimination on the basis of disability’. A focused group of experts and stakeholders is required to amalgamate ideas and align directions. This CS service in the GSD centre will unfold a new chapter in disability and oral health in Singapore.

Authors’ contributions
Lim GXD and Boyle CA planned the format and articles to be included. Lim GXD researched literature, gained ethical approval, data analysis, and produced the first draft of the manuscript. Both authors reviewed, edited, and approved the final version of the manuscript.

Availability of data and materials
The datasets generated from the author’s log are available from the corresponding author. Clinic data is subjected to Legal Aspect of Medical Confidentiality within Singapore and the National Dental Centre Singapore’s specific ethical board.

Ethical approval
The dataset generated from the author’s log was done in accordance to Declaration of Helsinki and Personal Data Protection Act (Singapore). Written approval was sought and accepted in 2017 by the National Dental Centre Singapore’s Ethics Review Board. No approval number was issued.

Informed consent
Not applicable.

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