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Background

Mild anxiolysis with nitrous oxide (N₂O) is a widely used pharmacologic behavior management technique in pediatric dentistry^{1,2,3,4}, providing both sedative and analgesic effects that facilitate treatment for anxious or uncooperative patients^{2,3}. However, children who require multiple N₂O-assisted dental visits may exhibit changes in cooperation over time¹. Current literature evaluating the longitudinal effects of repeated N₂O exposure on behavioral outcomes in pediatric dental patients remains limited and often reports conflicting findings^{1,5}. A clearer understanding of these behavioral patterns may help clinicians better anticipate patient cooperation and determine when alternative treatment strategies or behavior management approaches may be necessary.

Objectives

1. Evaluate whether behavior and cooperation change in children requiring multiple N₂O visits.
2. Identify alternative treatment modalities (including silver diamine fluoride application, Hall crown, protective stabilization, oral conscious sedation, and/or general anesthesia) when N₂O-assisted treatment cannot be completed.

We hypothesize that children requiring more than two nitrous oxide-assisted visits will show decreased cooperation over time, leading to increased need for adjunctive behavior management and alternative treatments (e.g., SDF, Hall crowns, MIPS, sedation, or general anesthesia).

Methods

Study Design

Retrospective chart review conducted at the Eastman Institute for Oral Health (EIOH) Pediatric Dentistry Clinic.

Study Period

Patients whose first nitrous oxide (N₂O) visit (D9230) occurred between January 1, 2020 and January 1, 2023.

Study Population

Children aged 3–12 years with ASA I–II who underwent nitrous oxide-facilitated dental treatment.

Inclusion Criteria

1. Age 3–12 years
2. ASA I–II
3. ≥2 N₂O-assisted dental treatment visits
4. First N₂O visit (D9230) between 2020–2023

Exclusion Criteria

1. Age <3 years or >12 years
2. ASA III–IV
3. History of dental care at non-EIOH facilities prior to enrollment.
4. Referral for treatment by medical or dental providers outside the URMIC EIOH Division of Pediatric Dentistry.

Statistical Analyses: Descriptive statistics summarized the study population. Kruskal–Wallis and Cochran–Mantel–Haenszel (CMH) tests were used to compare behavior management groups and assess the effects of treatment intervals and age on outcomes. Significance was set at $\alpha = 0.05$.

Category	Metric	Value
Age	Mean (+/- SD)	6.74 (+/-1.79) years
	Range	4 - 12 years
Sex	Female	28 (52.8%)
	Male	25 (47.2%)
Race	Caucasian	31 (58.5%)
	African American	16 (30.2%)
	Asian	5 (9.4%)
	American Indian	1 (1.9%)
Ethnicity	Non-Hispanic	38 (71.7%)
	Hispanic	14 (26.4%)
	Declined to state	1 (1.9%)
ASA	I	38 (71.7%)
	II	15 (28.3%)

Table 1: Patient Demographics and Clinical Characteristics (N=53)

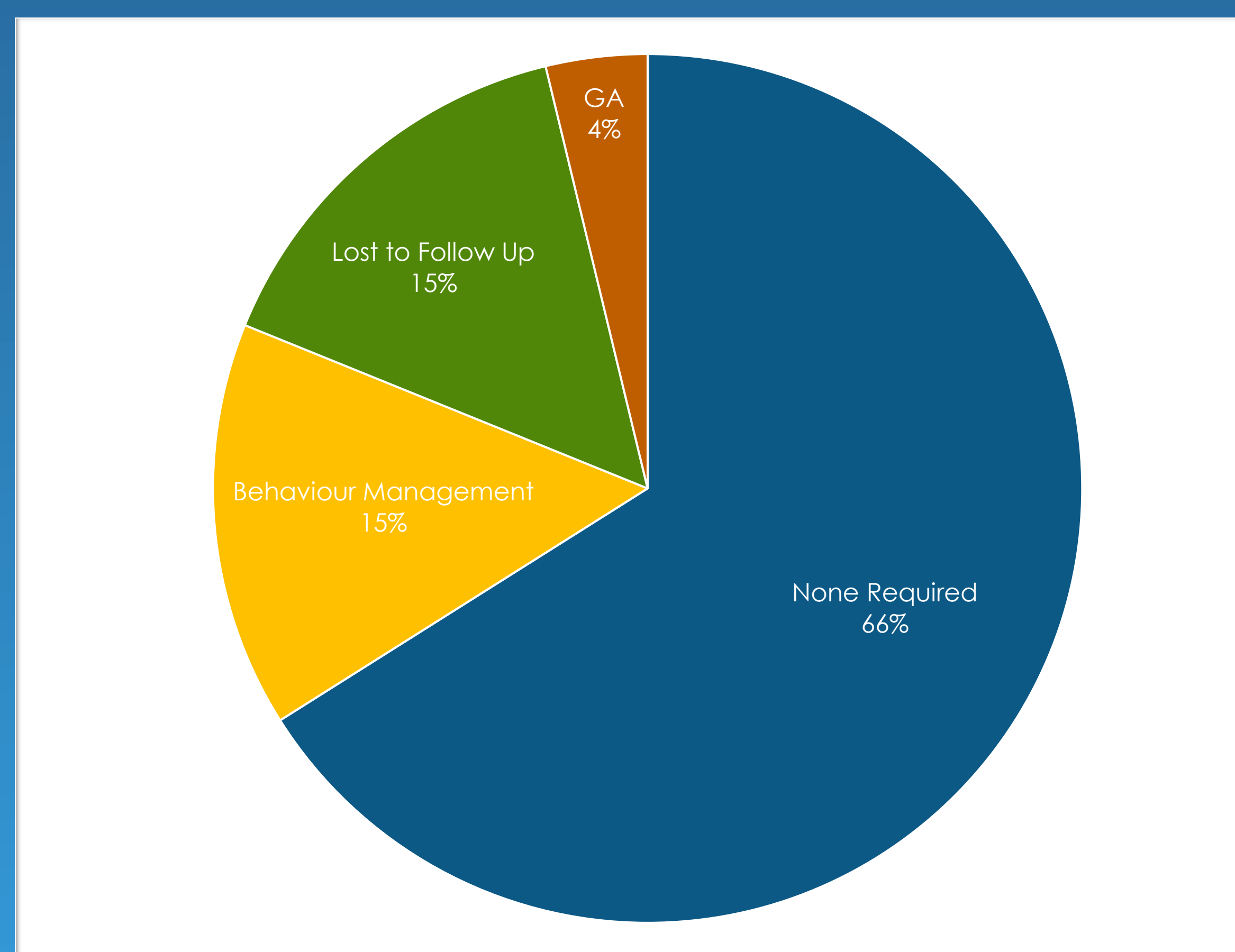


Figure 1. Behavior Technique Outcomes and Supplemental Behavior Management Requirements. Among the 53 patients analyzed, 33 (66%) successfully completed their treatment plan utilizing nitrous oxide (N₂O) alone, requiring no further intervention. Clinical transitions occurred in the remaining cohort: 8 patients (15.1%) completed their treatment by transitioning to non-pharmacological behavior management, and 8 patients (15.1%) were lost to follow-up after the initial N₂O sessions. Finally, 2 patients (3.8%) required an escalation to advanced behavior management, specifically general anesthesia (GA).

Results

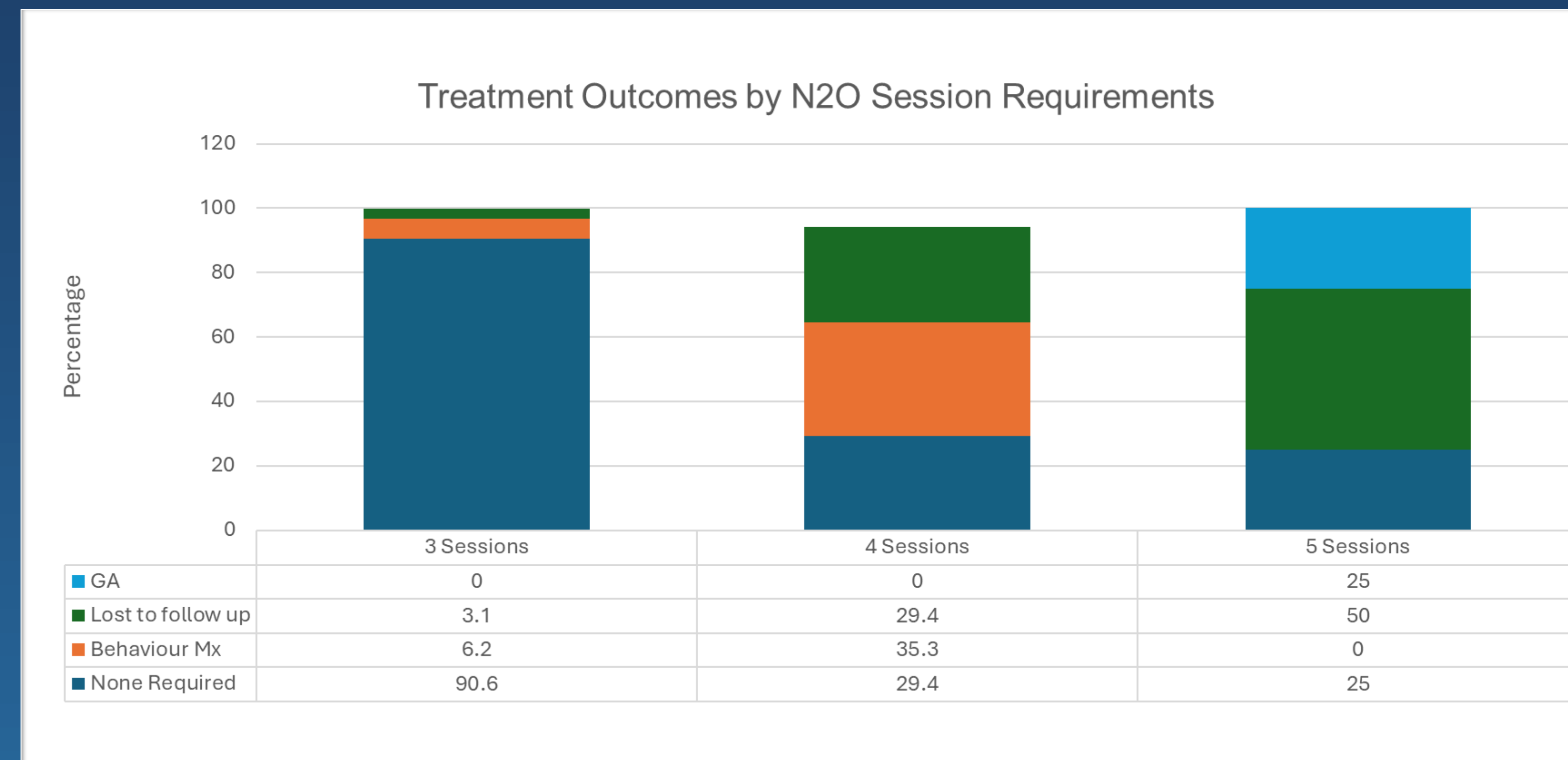


Figure 2. Treatment Outcomes by N₂O Session Requirements (N=53). The chart shows a decline in success ("None required") as session requirements increase. While patients requiring 3 sessions had a 90.6% success rate, those requiring 4 or 5 sessions exhibited higher attrition (29.4–50% lost to follow-up), and greater escalation to general anesthesia (GA) (25%).

Discussion

- **Comprehensive Protocol Outcomes:** Among 53 pediatric patients (mean age 6.7 ± 1.8), 66% (n=35) completed their multi-visit N₂O plan without additional intervention. Another 15.1% (n=8) showed positive behavioral transition, "graduating" to non-pharmacologic management. Protocol failure occurred in 18.9%, including lost to follow-up (15.1%) and escalation to general anesthesia (3.8%).
- **The CMH Analysis:** The Cochran-Mantel-Haenszel (CMH) test revealed a highly significant difference in the Row Mean Scores ($p < 0.001$), indicating that the four outcome groups reached their respective "endpoints" at different stages of the treatment plan.
 - **The Graduation Pathway (Behavior management):** Patients completed an average of 2.5 N₂O sessions before transitioning to non-pharmacologic management, suggesting N₂O served as a therapeutic "bridge" to build coping skills.
 - **The Escalation Pathway (GA):** Patients requiring GA reached their "tipping point" earlier, averaging only 2 sessions before protocol abandonment.
 - **The Success Pathway (None Required):** These patients showed the highest adherence, completing a mean of 3.23 N₂O sessions as planned.
- **Statistical Linear Trend:** A significant linear trend ($p = 0.0098$) showed that as session number increased, the likelihood of successful behavioral transition decreased, while protocol failure increased.
- **Independence from Age and Timing:** Kruskal-Wallis tests confirmed that neither Age ($p = 0.96$) nor Treatment Intervals ($p = 0.32$) significantly differed across outcome groups. This suggests that "treatment burnout" is not a function of the child's age/maturity or the length of time between appointments, but rather the cumulative burden of repeated pharmacological visits.
- **Escalation and Lost to Follow Up:** The "Lost to Follow-up" rate spiked from 3.1% (3 sessions) to 50% (5 sessions), while GA escalation reached 25% in the highest-need group (5 sessions). This highlights a clear clinical threshold, patients requiring ≥4 visits are at significantly higher risk for protocol failure.

Conclusions

- Most pediatric patients successfully completed N₂O-facilitated treatment or transitioned to non-pharmacologic management
- N₂O may function as a therapeutic "bridge" to improve coping and cooperation
- Patients requiring ≥4 visits showed increased risk of declining cooperation or protocol failure, leading to loss to follow-up or escalation to GA
- Repeated N₂O use may signal need for earlier alternative treatment strategies
- For high-need patients, providers should proactively discuss alternative treatment strategies (e.g., SDF⁷, Hall Crowns⁶, ITR) or advanced behavior management techniques (OCS/GA⁸) earlier in the process to prevent treatment fragmentation and patient attrition.

- **Confounding Factors:** Procedural invasiveness (restorative v.s. extraction), patient baseline anxiety level, parental dental anxiety, and varied N₂O concentrations/exposure times.

- **Future Directions:** Identify predictors of success versus escalation (e.g., baseline behavior and comorbidities), incorporating standardized Frankl scales in prospective trials, and conducting larger multi-center studies to validate findings.

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