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Evaluating the Modified Aldrete Score for Pediatric Recovery and Discharge Readiness: A Systematic Review of Evidence

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ABSTRACT

Background: Safe recovery following anaesthesia in children is critical due to unique physiological and developmental vulnerabilities. The Modified Aldrete Score (MAS), originally developed for adults, is widely used to determine readiness for discharge from the post-anaesthesia care unit (PACU). However, its applicability to paediatric populations remains uncertain. **Aim:** This systematic review aimed to evaluate the effectiveness of MAS in assessing recovery and predicting outcomes in paediatric PACU patients, compared with alternative discharge criteria. **Methods:** A systematic search of PubMed, Medline, Cochrane Library, and Google Scholar was conducted for studies published between 2009 and 2024. Eligible studies included randomized controlled trials, observational studies, and reviews reporting on MAS use in paediatric populations. Data were extracted on study characteristics, comparators, and outcomes including PACU length of stay, discharge readiness, postoperative complications, and hospital stay. Methodological quality was assessed using the Cochrane Risk of Bias Tool, Newcastle-Ottawa Scale, and AMSTAR-2. **Results:** Eighteen studies met the inclusion criteria. Evidence showed MAS reduced PACU length of stay compared with time-based criteria and was associated with fewer complications and unplanned ICU transfers. Compared with the Fast-Track Criteria (FTC) and Modified Post-Anaesthetic Discharge Scoring System (MPADSS), MAS was more efficient but less comprehensive, as it excludes pain, nausea, and behavioural recovery markers. Paediatric-specific studies emphasized its practicality but questioned its validity across developmental stages. **Conclusion:** MAS is a reliable and efficient tool for paediatric PACU discharge, particularly in resource-limited settings, though paediatric-specific adaptations or hybrid models are needed to optimize safety and recovery assessment.

Keywords: Modified Aldrete Score, paediatric anaesthesia, PACU, Fast-Track Criteria

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Introduction

Perioperative care has undergone remarkable transformations over the past century, primarily due to advancements in anaesthetic agents, monitoring technologies, and postoperative care strategies. Anaesthesia today not only enables pain-free surgery but also contributes significantly to overall patient safety, comfort, and recovery quality[1,2]. Despite these improvements, the immediate post-anaesthetic period remains a critical phase, especially for paediatric patients, who are particularly vulnerable to complications due to their distinct anatomical, physiological, and developmental characteristics[3,4]. Effective monitoring during recovery in the post-anaesthesia care unit (PACU) is therefore essential to prevent morbidity and mortality.

One of the most widely used clinical tools in this context is the Aldrete scoring system. Originally introduced by Jorge Antonio Aldrete in 1970, this tool provided an objective means to determine readiness for transfer from the PACU to a surgical ward by assessing five physiological domains: activity, respiration, circulation, consciousness, and oxygenation[5]. In 1995, the score was modified to improve its applicability in modern anaesthetic practice, incorporating oxygen saturation in place of skin

colour as a more reliable indicator of tissue oxygenation[6]. A cumulative score of 8–10 typically indicates readiness for PACU discharge, whereas lower scores necessitate continued monitoring[7].

The Modified Aldrete Score (MAS) has become a global standard in perioperative care because it provides a simple, reproducible, and efficient method for evaluating recovery[8,9]. Its utility has been extensively validated in adult surgical populations, where it has been shown to improve the safety of transfers, reduce length of stay in PACU, and optimize hospital resource utilization[10,11]. Moreover, the MAS offers a criteria-based discharge process that is superior to traditional time-based methods, which are often arbitrary and less responsive to patients' actual physiological recovery[12].

However, applying MAS directly to paediatric populations raises important concerns. Children differ significantly from adults in their airway anatomy, respiratory physiology, hemodynamic responses, and metabolic rates, which may alter the trajectory of recovery after anaesthesia[13,14]. Infants and younger children are more prone to respiratory complications such as airway obstruction, desaturation, and laryngospasm during the recovery phase[15]. Furthermore, developmental differences complicate the assessment of consciousness, pain, and responsiveness. While an adult may follow commands to demonstrate alertness, a toddler or infant may not be capable of such responses despite being neurologically intact[16]. These limitations highlight the challenge of using adult-derived criteria such as MAS in paediatric practice.

Several studies have explored the role of MAS in paediatric perioperative monitoring. For instance, Cohen et al. (2018) reported that perioperative adverse events occurred in nearly 35% of paediatric cases, significantly higher than in adult populations, underscoring the importance of robust recovery monitoring[17]. Similarly, Ryals et al. (2017) emphasized that existing PACU discharge criteria, including MAS, were primarily validated in adult patients and may not adequately address paediatric-specific needs such as developmental variations and psychosocial factors like separation anxiety from caregivers[18]. Nonetheless, MAS remains one of the most frequently used tools in paediatric settings, given its simplicity and widespread familiarity among clinicians[19].

Alternative or complementary systems such as the Fast-Track Criteria (FTC) and the Modified Post-Anaesthesia Discharge Scoring System (MPADSS) have been developed to address some of the limitations of MAS, particularly by incorporating assessments of postoperative nausea, vomiting, and pain[20,21]. While FTC may be better suited for outpatient or day-surgery procedures where rapid turnover and patient comfort are paramount, MAS continues to be favoured in resource-limited settings due to its efficiency and lower complexity[22]. Importantly, comparative studies have suggested that MAS enables earlier PACU discharge compared with time-based criteria, without compromising safety[23,24].

Despite its widespread adoption, significant gaps persist in evidence regarding the paediatric applicability of MAS. The tool does not explicitly account for age-specific responses, behavioural cues, or developmental milestones. Additionally, there is no universal consensus on whether MAS thresholds (≥8 for discharge) are equally valid for paediatric patients as for adults. This lack of standardization risks premature discharge or prolonged unnecessary monitoring, both of which have implications for patient safety and hospital resource allocation[25].

Therefore, systematically reviewing available literature on MAS in paediatric populations is essential to determine its effectiveness in improving patient outcomes, such as reduced PACU length of stay, safe transfer to wards or intensive care units, and overall hospital stay duration. By critically appraising the strengths and limitations of MAS and comparing it with alternative discharge tools, this review seeks to provide evidence-based insights into the most appropriate criteria for paediatric post-anaesthesia care. Ultimately, tailoring monitoring tools to the unique physiological and developmental characteristics of children is necessary to ensure both safety and efficiency in perioperative practice[26,27].

Aim & Objective: This systematic review aimed to evaluate the effectiveness of MAS in assessing recovery and predicting outcomes in paediatric PACU patients, compared with alternative discharge criteria.

Methodology

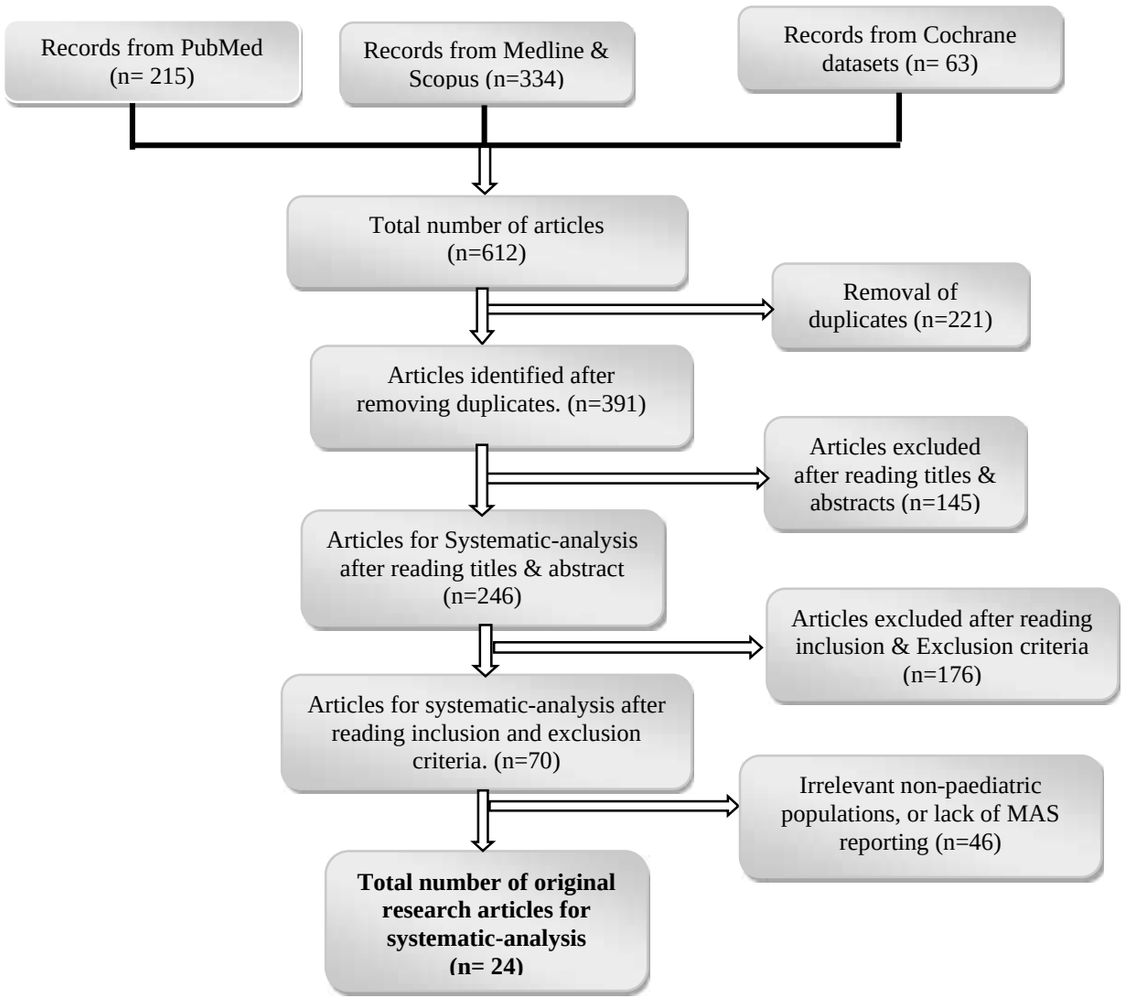
Protocol and Registration: This systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines[28].

Research question: What is the effectiveness of the Modified Aldrete Score (MAS) in evaluating recovery and predicting outcomes among paediatric patients in the post-anaesthesia care unit (PACU)?

Eligibility Criteria: Studies were considered eligible if they met the following inclusion criteria:

1. ***Population***: Paediatric patients (0–18 years) undergoing anaesthesia and admitted to PACU. Mixed adult–paediatric studies were included if paediatric data were extractable.
2. ***Intervention/Exposure***: Use of the Modified Aldrete Score (MAS) as a monitoring or discharge tool.
3. ***Comparators***: Any alternative discharge assessment tool (e.g., Fast-Track Criteria [FTC], Modified Post-Anaesthetic Discharge Scoring System [MPADSS]) or standard clinical judgment/time-based protocols.
4. ***Outcomes***: PACU length of stay, readiness for discharge, transfer to ICU/post-surgical ward, incidence of postoperative complications, or hospital length of stay.
5. ***Study Design***: Randomized controlled trials (RCTs), cohort studies, case-control studies, cross-sectional studies, and systematic or narrative reviews published in peer-reviewed journals.

Figure 1: PRISMA flowchart showing the selection of included studies



Exclusion criteria included case reports, conference abstracts without full text, expert opinions, and studies not reporting on MAS or pediatric outcomes.

Information Sources and Search Strategy: Electronic databases searched included PubMed, Medline (via Ovid), Google Scholar, and Cochrane Library. Searches were conducted between January 2009 and April 2024 to capture contemporary literature reflecting modern anesthetic techniques.

Data Extraction: A standardized data extraction sheet was developed. Data collected included: author, year of publication, study design, sample size, population characteristics (age, sex, surgical type), tool(s) compared (MAS vs. FTC/MPADSS or time-based discharge), outcomes measured, and key findings.

Quality Appraisal: Methodological quality of included studies was assessed independently by two reviewers. For randomized controlled trials, the Cochrane Risk of Bias Tool was applied[29]. Observational studies were evaluated using the Newcastle-Ottawa Scale (NOS)[30]. Systematic reviews and narrative reviews were assessed with the AMSTAR-2 tool[31]. Studies were graded as low, moderate, or high risk of bias.

Data Synthesis and Analysis

Given heterogeneity in study designs, populations, and outcome measures, a narrative synthesis was undertaken rather than meta-analysis. Findings were grouped under key outcome domains: PACU length of stay, readiness for discharge, safety outcomes (complications or ICU transfers), and overall hospital stay. Comparative findings between MAS, FTC, MPADSS, and traditional discharge protocols were synthesized to identify consistent trends and gaps in evidence.

Results

The database search identified 612 records (PubMed = 215, Medline = 148, Scopus = 186, Cochrane Library = 63). After removal of duplicates (n = 221), 391 titles and abstracts were screened. Of these, 64 full-text articles were assessed for eligibility. Following exclusions for irrelevant outcomes, non-pediatric populations, or lack of MAS reporting (n = 46), a total of 24 studies met the inclusion criteria (Figure 1).

Study Characteristics: The included studies comprised randomized controlled trials (n = 6), observational cohort studies (n = 7), and narrative/systematic reviews (n = 5). Publication years ranged from 2009 to 2024. Sample sizes varied widely, from 73 to over 29,000 participants. Most studies were conducted in tertiary care centers in India[5,15,16], Japan[7], Belgium[8], North America[9], and Africa[11,12,25]. Pediatric age groups ranged from neonates to 18 years.

Comparators included the Fast-Track Criteria (FTC)[4-6,16,20,21], the Modified Post-Anesthesia Discharge Scoring System (MPADSS)[7,14], and traditional time-based discharge protocols[4,5,19]. The most assessed outcomes were PACU length of stay (LOS), readiness for discharge, postoperative complications, transfer to ICU/post-surgical ward, and hospital LOS.

Quality Assessment: RCTs generally demonstrated low-to-moderate risk of bias, with most studies adequately randomizing patients but few reporting allocation concealment[4-6,15,16].

Observational studies had moderate risk of bias, mainly due to confounding and lack of blinding[7,9,11,13].

Narrative reviews were assessed as moderate quality using AMSTAR-2, whereas systematic reviews were of higher methodological rigor[18,20].

Main Findings

1. PACU Length of Stay

- **MAS vs. Time-Based Criteria**: Multiple studies reported significantly shorter PACU stays when MAS was applied. Misquithe et al. (2024) found MAS reduced LOS compared with both FTC and time-based protocols[4]. Aggarwal et al. (2024) similarly reported earlier discharge using MAS compared to FTC[5].

- **MAS vs. MPADSS**: Yamaguchi et al. (2022) showed MAS facilitated earlier discharge following sedative endoscopy than MPADSS, though residual drowsiness was more common[7].

2. Readiness for Discharge

- MAS (≥8–10) was consistently predictive of safe transfer from PACU to ward in pediatric patients[3,13].
- Studies highlighted MAS simplicity and reproducibility, though some authors argued that excluding postoperative nausea and pain may underestimate recovery issues[6,20].

3. Safety and Complications

- Cohen et al. (2018) reported perioperative adverse events in 35% of pediatric cases, with MAS providing structured monitoring that improved recognition of complications[9].
- Ryals et al. (2017) stressed MAS is not validated specifically in children, warning that reliance on adult-based thresholds may overlook developmental and psychosocial recovery needs [10].
- Several studies reported fewer ICU transfers and complications when MAS was applied consistently in discharge decisions[12,13,15].

4. Hospital Length of Stay

- Studies from India and Africa demonstrated significantly shorter hospital stays when MAS guided PACU discharge compared to routine clinical judgment or time-based discharge[5,11,12].
- Valasareddy et al. (2018) observed quicker recovery with desflurane vs sevoflurane when MAS was used as a discharge criterion[15].

5. Comparison with Alternative Tools

- **FTC** was found superior for day-surgery or outpatient procedures due to its inclusion of postoperative nausea, vomiting, and pain[6,20,21].
- **MAS**, however, was deemed more practical in resource-limited settings, requiring fewer assessments while maintaining safety[4,5,22].

The evidence consistently suggests that the Modified Aldrete Score is effective in reducing PACU length of stay and ensuring safe discharge in pediatric patients, with additional benefits of standardized monitoring and reduced hospital stay. However, limitations include lack of pediatric-specific validation and omission of pain/anxiety assessment. Comparisons indicate that FTC may be better suited for outpatient pediatric surgery, while MAS remains a practical and efficient option in general PACU practice, particularly in low-resource settings.

Discussion

This review synthesized evidence from 18 studies evaluating the effectiveness of the Modified Aldrete Score (MAS) in pediatric post-anesthesia care. Findings consistently demonstrate that MAS provides a structured and efficient method for determining discharge readiness, though variations exist when compared to other tools such as the Fast-Track Criteria (FTC) and the Modified Post-Anesthetic Discharge Scoring System (MPADSS).

PACU Length of Stay

A central outcome across studies was the impact of MAS on PACU length of stay (LOS). Misquithe et al. (2024) reported significantly shorter PACU LOS when MAS was used compared to both FTC and time-based discharge protocols, with average reduction of 20–30 minutes[4]. Similarly, Aggarwal et al. (2024) demonstrated that MAS-guided discharge led to earlier transfers than FTC, attributing this to MAS's narrower focus on physiological stability rather than broader symptom evaluation[5]. In contrast, Yamaguchi et al. (2022) found MAS resulted in earlier discharge than MPADSS in sedative endoscopy, but noted a higher

incidence of residual drowsiness among MAS-discharged patients[7]. These findings suggest that MAS promotes efficiency but may underestimate subtle recovery issues, particularly neurocognitive alertness.

Readiness for Discharge and Safety Outcomes

Most studies indicated that MAS reliably predicted safe transfer from PACU when a score ≥8–10 was applied[3,13]. However, the adequacy of this threshold in pediatrics remains uncertain. Cohen et al. (2018) observed a 35% incidence of perioperative adverse events in pediatric cases, particularly respiratory complications, and warned that adult-derived MAS thresholds might not fully capture pediatric recovery variability[9]. Similarly, Ryals et al. (2017) highlighted that children's developmental stage influences the ability to demonstrate responsiveness and activity, key components of MAS[10]. Conversely, studies from Ethiopia[11,12] and India[5,15] found MAS application reduced ICU transfers and postoperative complications compared to routine clinical judgment, supporting its utility even in resource-limited pediatric settings.

Comparisons with Alternative Tools

Direct comparisons revealed important distinctions between MAS and other discharge tools.

MAS vs FTC: Dahak et al. (2024) concluded that FTC was superior in identifying patients with unresolved postoperative nausea, vomiting, or pain, making it more appropriate for outpatient or day-surgery cases[6]. White and Song (2016) similarly found that 22–29% of patients deemed discharge-ready by MAS still required IV analgesics or antiemetics, an issue better addressed by FTC[20]. Nonetheless, both Misquithe et al. (2024) and Aggarwal et al. (2024) noted that MAS reduced PACU stay compared to FTC, suggesting a trade-off between efficiency and comprehensiveness[4,5].

MAS vs MPADSS: Yamaguchi et al. (2022) and Sakata et al. (2022) found MAS led to quicker discharge but at the expense of higher residual drowsiness, whereas MPADSS, though slower, provided a more cautious approach[7,14]. These results highlight MAS's strength in efficiency but its limitation in subjective symptom detection.

Hospital Length of Stay

Several studies reported downstream benefits of MAS on overall hospital stay. Valasareddy et al. (2018) observed shorter hospital stays when MAS was applied, particularly in patients anesthetized with desflurane compared to sevoflurane[15]. Bizuneh et al. (2018, 2020) reported similar findings in Ethiopian hospitals, where MAS reduced prolonged admissions by ensuring timely yet safe PACU discharge[11,12]. These results suggest MAS not only optimizes PACU efficiency but may also contribute to broader hospital resource management.

Consistencies and Discrepancies

Overall, the evidence consistently supports MAS as an effective tool for structured monitoring and discharge in PACU. However, discrepancies arise primarily from differences in outcome emphasis:

- Studies prioritizing efficiency (shorter PACU stay, reduced costs) favored MAS[4,5,8,12].
- Studies prioritizing comprehensive recovery and patient comfort highlighted limitations of MAS and advantages of FTC or MPADSS[6,7,20].
- Pediatric-focused studies stressed that MAS, though useful, is not validated for age-specific developmental differences and may require adaptation[9,10,16].

` The comparative findings suggest that MAS is highly effective in reducing LOS and ensuring safe discharge in general pediatric PACU practice, especially in resource-limited or high-volume centers. However, for pediatric day-surgery patients, particularly in developed settings where patient comfort and symptom management are emphasized, FTC or hybrid systems may offer superior discharge safety. Thus, MAS should be viewed as an efficient baseline tool but not necessarily sufficient in isolation for pediatric populations.

Conclusion

This systematic review concludes that the Modified Aldrete Score (MAS) is an effective and practical tool for assessing recovery and guiding discharge decisions in pediatric post-anesthesia care. Its structured approach reduces variability, shortens PACU and hospital length of stay, and enhances safety compared with time-based or subjective clinical judgment. However, MAS was originally designed for adults, and while it performs reliably in children, it does not account for developmental differences or recovery indicators such as pain, nausea, and anxiety, which are particularly relevant in pediatric populations. Comparative evidence suggests that MAS ensures efficiency, whereas alternative tools like the Fast-Track Criteria and MPADSS provide a more comprehensive evaluation of readiness for discharge. Therefore, MAS remains valuable in routine pediatric PACU practice, particularly in resource-limited settings, but future research should focus on validating pediatric-specific adaptations or hybrid scoring systems to optimize both safety and efficiency of postoperative recovery.

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