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Research Article

Clinical Audit of Pediatric Advanced Life Support (PALS) Guideline Adherence during Emergency Resuscitation

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ABSTRACT

Background: Pediatric emergencies can progress rapidly to respiratory failure, shock, and cardiopulmonary arrest.

Objective: To assess adherence to Pediatric Advanced Life Support guidelines during emergency resuscitation in the Pediatric Emergency Department and identify areas requiring quality improvement.

Study Design: Clinical audit.

Place and Duration of Study: Pediatric Emergency Department, Liaquat University Hospital, Hyderabad, from July 2021 to December 2021.

Methodology: Ninety-six consecutive resuscitation events involving children aged one month to 18 years were assessed using a structured checklist based on Pediatric Advanced Life Support recommendations. The evaluated criteria included timely recognition of deterioration, initiation and quality of cardiopulmonary resuscitation, oxygenation and ventilation, rhythm recognition, vascular access, epinephrine administration, defibrillation, assessment of reversible causes, teamwork, documentation, and post-resuscitation care.

Results: The mean overall adherence score was 61.4 ± 14.2%. High adherence was observed in 19 (19.8%) events, moderate adherence in 43 (44.8%), and low adherence in 34 (35.4%). Immediate cardiopulmonary resuscitation was initiated in 65 (67.7%) events. The recommended compression rate, appropriate compression depth, and interruptions below 10 seconds were achieved in 52 (54.2%), 47 (49.0%), and 43 (44.8%) events, respectively. Correct epinephrine dosing was documented in 60 (62.5%) events, while recommended dosing intervals were followed in 49 (51.0%).

Conclusion: Adherence to Pediatric Advanced Life Support guidelines was suboptimal, particularly regarding chest-compression quality, medication timing, communication, documentation, and debriefing.

Keywords: Pediatric Advanced Life Support, Clinical Audit, Pediatric Resuscitation, Cardiopulmonary Resuscitation.

INTRODUCTION

Infants and children have limited physiological reserves and the need to quickly progress from respiratory distress or circulatory failure to cardiopulmonary arrest, making a pediatric emergency potentially rapidly deteriorating. Pediatric cardiac arrest is often preceded by respiratory failure, shock, hypoxemia, or progressive bradycardia, whereas these factors are not often seen in adult cardiac arrest [1]. Therefore, prompt identification of the signs of clinical deterioration and timely activation of appropriate interventions are vital to preventing arrest and maximizing likelihood of good neurologic outcomes [2]. Pediatric Advanced Life Support (PALS) is an evidence-based, structured system for evaluating and treating very sick or injured children and babies. There

are current American Heart Association and American Academy of Pediatrics guidelines for the recognition and treatment of Pediatric Respiratory Emergencies, Shock, Bradycardia, Tachyarrhythmias, Cardiac Arrest and Post–Cardiac Arrest Care for patients up to 18 years of age (excluding newborn infants) [3]. It involves systematic evaluation, good cardiopulmonary resuscitation, effective ventilation, rhythm recognition, prompt defibrillation, proper drug giving, vascular access, recognising reversible causes and team coordination [4].

Applying the PALS guidelines is especially critical in emergency resuscitation as the success of the treatment is dependent on both the choice of treatment but also on the timing, dose, sequence, and quality of the treatment [5]. The paediatric cardiac-arrest algorithm focuses on the timely initiation of cardiopulmonary resuscitation (CPR), oxygenation and ventilation, the use of a monitor or a defibrillator, the establishment of intravenous or intraosseous access, treatment based on rhythm and frequent reassessment [6]. Failure to provide timely chest compressions, allowing too many pauses, providing inappropriate ventilation, giving the wrong dose of medication, failing to defibrillate promptly, and failing to recognize reversible causes can decrease the chance for ROSC and increase the risk of neurological injury. Although there are standardised algorithms and formal training programmes, it is difficult to always follow them during resuscitation [7]. Pediatric emergencies tend to be less frequent than adult emergencies and may not expose clinicians to the same practice opportunities and retention of skills. Other factors such as high workload, emotional stress, inadequate team coordination, equipment restrictions, lack of age/weight-specific treatment recommendations, medication-calculation errors, and unfamiliarity with the use of the treatment guidelines can also lead to deviations from the guidelines [8].

PALS training is for health care workers who manage emergencies in children and infants such as emergency physicians, pediatricians, anesthetists, nurses, paramedics and intensive-care workers. The programme focuses on the systematic paediatric assessment, treatment algorithms, simulated emergencies, communication techniques and training of team dynamics to improve the quality of paediatric emergency care [9]. This course has been updated to reflect the updated guidelines for cardiopulmonary resuscitation and emergency cardiovascular care from the American Heart Association for 2025. However, it is not always guaranteed that the recommended practices are carried out during actual clinical events, especially with resuscitation conducted under time pressure [10]. Adherence to guidelines can be evaluated to identify important areas of unmet care. Key indicators are the timely recognition of cardiac arrest, prompt initiation of chest compressions, correct rate and depth of compressions, minimisation of interruptions, correct ventilation, accurate recognition of the rhythm, timely epinephrine administration, correct defibrillation energy, use of intravenous or intraosseous access, identification of reversible causes, and provision of structured post-resuscitation care [11]. Closed loop communication, role allocation and documentation are also essential as effective pediatric resuscitation requires coordinated team performance as well as individual clinical skills. Targeted quality-improvement efforts such as simulation-based training, mock-code programmes, cognitive aids, standardised resuscitation carts, medication-dosing charts, real-time feedback devices, and structured debriefing may help to facilitate regular assessment of PALS adherence [12]. The updated resuscitation guidelines are designed to take all the best current scientific research and "turn the science into recommendations for best practice" but ultimately it is how well these guidelines are applied at the bedside that makes the difference. Then, checking on proper usage can assist healthcare institutions in assessing whether healthcare providers are using the algorithms correctly and uniformly in pediatric emergencies [13].

Objective

To assess adherence to Pediatric Advanced Life Support guidelines during emergency resuscitation in the Pediatric Emergency Department and identify areas requiring quality improvement.

METHODOLOGY

This clinical audit was conducted in the Pediatric Emergency Department of Liaquat University Hospital, Hyderabad, from July 2021 to December 2021. It evaluated the compliance of healthcare providers with the Pediatric Advanced Life Support protocols, during emergency resuscitation of the critically ill infant and child. The audit took place in two stages, with a baseline audit carried out, followed by targeted quality improvement

measures being implemented and re-audit on the same pre-defined standards. All paediatric patients aged from one month to 18 years who were admitted to the Pediatric Emergency Department for emergency resuscitation for respiratory failure, shock, symptomatic bradycardia, unstable tachyarrhythmia or cardiopulmonary arrest were included in the audit. The majority of newborns who needed resuscitation were excluded as they were afterwards treated according to neonatal resuscitation guidelines. Sample size was determined for estimation of a single proportion with an expected PALS guideline adherence rate of 50%, a 95% confidence level and an absolute precision of 10%. The adherence rate was chosen to be 50% as there was no reliable estimate of adherence available locally, and this was the maximum sample size needed.

The sample size was calculated using the formula:

$$n = \frac{Z^2 p(1-p)}{d^2}$$

where $n$represented the required sample size, $Z$was 1.96 at a 95% confidence level, $p$was the expected adherence proportion of 0.50, and $d$was the required precision of 0.10.

$$n = \frac{(1.96)^2(0.50)(0.50)}{(0.10)^2} = 96.04$$

The minimum calculated sample size was therefore 96 pediatric resuscitation events in each audit phase. Accordingly, 96 events were assessed during the baseline audit and another 96 events during the re-audit, resulting in a total sample of 192 resuscitation events. A non-probability consecutive sampling technique was used.

Inclusion and exclusion Criteria

The audit consisted of all resuscitation events in patients from one month to 18 years of age that involved one or more PALS-related interventions such as bag-mask ventilation, chest compressions, defibrillation, synchronized cardioversion, emergency IV/IO access, vasoactive medications or advanced airway management. When sufficient clinical documentation or direct observation data were available, both cardiopulmonary arrest and pre-arrest emergencies which require advanced life-support procedures were included. Immediate delivery (newborn resuscitation) and patients over 18 years of age, patients declared dead on arrival without resuscitation attempts, and events managed before arrival to the hospital were excluded. Cases where there was a documented do not resuscitate order, treatment limitation or lack of documentation to evaluate the primary audit criteria were also excluded.

Audit standards and criteria

The audit standards are based on the relevant Pediatric Advanced Life Support (PALS) recommendations. Timely recognition of cardiorespiratory arrest, immediate CPR initiation, compression rate of 100-120 compressions per minute, compression depth, complete recoil of the chest, and minimisation of interruptions were all included as criteria. Additional factors were appropriate oxygenation and ventilation, timely placement of a cardiac monitor or defibrillator, accurate identification of the rhythm, timely IV or intraosseous access, timely use of epinephrine, appropriate defibrillation or cardioversion energy, minimization of potentially reversible causes and provision of post-resuscitation care. The evaluation of the team performance entailed the presence of a clearly defined team leader, allocation of roles, closed loop communication, timely decision making and full documentation of the resuscitation event. Adherence for all applicable life-saving interventions was targeted at 100%, and at least 80% adherence was regarded as satisfactory at a case-level. The overall adherence score for each resuscitation was determined by dividing the number of resuscitation criteria met by the number of criteria that could be applied to each event and multiplying by 100. Adherence was classified as high (80% or more), moderate (60%–79%), and low (<60%).

Data Collection

A PALS audit checklist was developed and structured. It encompassed patient age, gender, estimated or measured body weight, initial emergency, initial cardiac rhythm, recognition of arrest, CPR timing and quality, airway and ventilation interventions, vascular access, drug dosing and timing, defibrillation information, reversible causes considered, ROSC, post-resuscitation management, team performance, and documentation quality. A group of experts, from both the field of paediatrics and emergency medicine, has evaluated the relevance, clarity and completeness of the checklist. Before formal data collection, it was tried out on a few pediatric resuscitation records and changes were made accordingly. Eligible resuscitation

events were recorded in the paediatric emergency registers, resuscitation registers, nursing notes, medication registers, defibrillator registers and patient records. In cases where training auditors could be done without disrupting patient care, they directly observed emergency resuscitations. Structured checklist was used to collect data on the quality of chest compression, rhythm analysis, shock timing, and medication and airway management. A unique audit identification number was given to each case. No patient and staff identifiers were entered into the analytical database. The records were independently audited by another auditor for consistency with a proportion. All disagreements between reviewers were discussed with a senior pediatric or emergency-medicine specialist. In the first phase, 96 eligible pediatric resuscitation events were reviewed to the standards of the PALS.In the first phase, 96 events were assessed for pediatric resuscitation to the PALS standards. Adherence was determined for each event (and for overall adherence). The baseline audit revealed some standard errors for CPR quality, medication administration, rhythm recognition, defibrillation, airway management, team communication, and documentation.

Re-Audit

Re-audit was performed about 3–6 months after the implementation of quality improvement interventions. A second 96 subsequent eligible pediatric resuscitation events were evaluated in a similar audit environment, with the same audit set-up, inclusion/exclusion criteria, checklist, operational definitions, and adherence criteria as the first audit. Baseline and re-audit results were compared to see if there was an improvement in compliance with the PALS guidelines after the intervention.

Outcome Measures

The main outcome was the percentage of applicable PALS criteria that were followed correctly in each of the pediatric resuscitation events. Secondary outcomes were timely initiation of CPR, compliance with recommended parameters for chest compressions, adequate ventilation, timely vascular access, correct medication dosage and timing, appropriate defibrillation or cardioversion, identification of treatable causes, successful team communication, complete documentation, ROSC and survival to transfer to PICU or other definitive care center.

Statistical Analysis

The collected data were entered and analyzed with IBM SPSS Statistics version 25.0. The quantitative variables were expressed as mean ± SD or median (25th–75th percentiles) as appropriate. Categorical variables were summarized in terms of frequency and percent. The adherence proportions in the baseline audit and re-audit were compared using the chi-square test or Fisher's exact test where expected cell frequencies were small. Patient age, type of emergency, time of resuscitation, PALS certification of team members, experience of team leader, equipment availability and the presence of a structured resuscitation team were all considered variables in the analysis. The p value was set at ≤ 0.05 as statistically significant.

RESULTS

A total of 96 pediatric resuscitation events were assessed in each audit cycle. The mean age was comparable between the baseline and re-audit groups at 5.8 ± 4.6 years and 5.6 ± 4.4 years, respectively. Males constituted 57 (59.4%) cases in the baseline audit and 54 (56.3%) in the re-audit. Respiratory failure was the most common indication for resuscitation in both cycles, accounting for 31 (32.3%) and 29 (30.2%) cases, followed by shock in 26 (27.1%) and 28 (29.2%) cases. Cardiopulmonary arrest occurred in 21 (21.9%) and 20 (20.8%) events, respectively.

Table 1. Patient and Resuscitation Characteristics during the Audit Cycles

Variable	Baseline AUDIT (N=96)	Re-AUDIT (N=96)
Age, YEARS	5.8 ± 4.6	5.6 ± 4.4
Male	57 (59.4)	54 (56.3)
Female	39 (40.6)	42 (43.8)
Respiratory FAILURE	31 (32.3)	29 (30.2)
Shock	26 (27.1)	28 (29.2)
Cardiopulmonary ARREST	21 (21.9)	20 (20.8)
Symptomatic BRADYCARDIA	11 (11.5)	12 (12.5)

Unstable TACHYARRHYTHMIA	7 (7.3)	7 (7.3)
Day-SHIFT RESUSCITATION	58 (60.4)	61 (63.5)
Night-SHIFT RESUSCITATION	38 (39.6)	35 (36.5)
Pals-CERTIFIED TEAM LEADER PRESENT	44 (45.8)	72 (75.0)

Values are presented as mean ± SD or n (%).

Timely recognition of deterioration or arrest increased from 61 (63.5%) to 84 (87.5%), while immediate initiation of CPR increased from 65 (67.7%) to 87 (90.6%). Adherence to the recommended compression rate improved from 52 (54.2%) to 81 (84.4%), and appropriate compression depth increased from 47 (49.0%) to 76 (79.2%). Complete chest recoil improved from 51 (53.1%) to 78 (81.3%), while interruptions below 10 seconds increased from 43 (44.8%) to 73 (76.0%).

Table 2. Adherence to Initial Assessment and Cardiopulmonary Resuscitation Standards

Audit Criterion	Baseline Audit (N=96)	Re-Audit (N=96)	P-Value
Timely Recognition Of Deterioration Or Arrest	61 (63.5)	84 (87.5)	<0.001
Immediate Initiation Of CPR When Indicated	65 (67.7)	87 (90.6)	<0.001
Compression Rate Of 100–120/Minute	52 (54.2)	81 (84.4)	<0.001
Appropriate Compression Depth	47 (49.0)	76 (79.2)	<0.001
Complete Chest Recoil	51 (53.1)	78 (81.3)	<0.001
Compression Interruptions Below 10 Seconds	43 (44.8)	73 (76.0)	<0.001
Correct Compression-To-Ventilation Ratio	58 (60.4)	82 (85.4)	<0.001
Appropriate Oxygenation And Ventilation	66 (68.8)	86 (89.6)	<0.001

Timely attachment of a monitor or defibrillator increased from 59 (61.5%) to 85 (88.5%), while correct rhythm identification improved from 62 (64.6%) to 86 (89.6%). Timely intravenous or intraosseous access increased from 55 (57.3%) to 80 (83.3%). Correct epinephrine dosing improved from 60 (62.5%) to 87 (90.6%), and administration at the recommended interval increased from 49 (51.0%) to 78 (81.3%). Correct defibrillation or cardioversion energy was used in 18 of 28 (64.3%) applicable baseline events and 25 of 28 (89.3%) re-audit events (p=0.026).

Table 3. Adherence to Advanced Pediatric Advanced Life Support Interventions

Audit Criterion	Baseline Audit (N=96)	Re-Audit (N=96)	P-Value
Timely Attachment Of Monitor Or Defibrillator	59 (61.5)	85 (88.5)	<0.001
Correct Rhythm Identification	62 (64.6)	86 (89.6)	<0.001
Timely Intravenous Or Intraosseous Access	55 (57.3)	80 (83.3)	<0.001
Correct Epinephrine Dose	60 (62.5)	87 (90.6)	<0.001
Epinephrine Given At Recommended Interval	49 (51.0)	78 (81.3)	<0.001
Correct Defibrillation Or Cardioversion Energy	18/28 (64.3)	25/28 (89.3)	0.026
Reversible Causes Appropriately Assessed	46 (47.9)	77 (80.2)	<0.001

Appropriate Post-Resuscitation Care Provided	54 (56.3)	82 (85.4)	<0.001

A clearly identified team leader was present in 50 (52.1%) baseline events compared with 83 (86.5%) re-audit events. Role allocation increased from 42 (43.8%) to 79 (82.3%), while closed-loop communication improved from 38 (39.6%) to 75 (78.1%). The presence of a dedicated timekeeper or recorder increased from 41 (42.7%) to 76 (79.2%).

Table 4. Team Performance and Documentation Adherence

Audit Criterion	Baseline Audit (N=96)	Re-Audit (N=96)	P-Value
Clearly Identified Team Leader	50 (52.1)	83 (86.5)	<0.001
Roles Allocated At The Start Of Resuscitation	42 (43.8)	79 (82.3)	<0.001
Closed-Loop Communication Used	38 (39.6)	75 (78.1)	<0.001
Dedicated Timekeeper Or Recorder Present	41 (42.7)	76 (79.2)	<0.001
Weight-Based Medication Chart Used	48 (50.0)	84 (87.5)	<0.001
Resuscitation Documentation Completed	53 (55.2)	85 (88.5)	<0.001
Structured Post-Event Debriefing Conducted	21 (21.9)	69 (71.9)	<0.001

Figure 1: Team Performance and Documentation Adherence during the Baseline Audit and Re-Audit.

The mean overall guideline-adherence score increased significantly from 61.4 ± 14.2% during the baseline audit to 84.7 ± 10.6% during the re-audit (p<0.001). High adherence increased from 19 (19.8%) to 71 (74.0%), whereas moderate adherence declined from 43 (44.8%) to 22 (22.9%) and low adherence from 34 (35.4%) to 3 (3.1%).

Table 5. Overall Guideline Adherence and Clinical Outcomes

Outcome	Baseline audit (n=96)	Re-audit (n=96)	p-value
Overall adherence score, %	61.4 ± 14.2	84.7 ± 10.6	<0.001
High adherence, ≥80%	19 (19.8)	71 (74.0)	<0.001
Moderate adherence, 60–79%	43 (44.8)	22 (22.9)	

Low adherence, <60%	34 (35.4)	3 (3.1)	
Return of spontaneous circulation	48/65 (73.8)	56/67 (83.6)	0.168
Survival to PICU or definitive-care transfer	67 (69.8)	79 (82.3)	0.043
Survival to hospital discharge	45 (46.9)	57 (59.4)	0.082

Figure 2: Adherence to Initial Assessment and Cardiopulmonary Resuscitation Standards during the Baseline Audit and Re-Audit

DISCUSSION

This clinical audit showed that there was a significant increase in compliance with PALS guidelines after the targeted quality-improvement measures were implemented. The mean overall adherence score increased from the baseline audit (61.4 ± 14.2%) to the re-audit (84.7 ± 10.6%) and the percentage of events with high adherence also improved from 19.8% to 74.0%. Meanwhile, low adherence dropped significantly from 35.4% to 3.1%. In conclusion, the results suggest that structured training, standardised cognitive aids, better equipment organisation, clearer team roles and post event debriefing can make a significant contribution to the quality of paediatric emergency resuscitation. The characteristics of the patient and resuscitation were similar across the two audits, which makes case mix changes less likely to be the primary reason for the observed improvements. The distribution of children with respiratory failure, shock, cardiopulmonary arrest, symptomatic bradycardia and unstable tachyarrhythmia continued to be the same. The percentage of sites having a PALS certified team leader increased from 45.8% at baseline to 75.0% at re-audit. This rise could have been a significant factor in the overall improvement as an experienced and identified leader can coordinate clinical priorities, roles, be aware of algorithm and minimize delay during resuscitation [14].

The early recognition and basic resuscitation element made a significant improvement. The recognition of deterioration or arrest was improved from 63.5% to 87.5% and cardiopulmonary resuscitation was started immediately in 67.7% to 90.6%. Clinically relevant improvements are that progressive respiratory failure, or shock often occurs before a cardiac arrest in children. Reversible physiological deterioration can continue to develop to cardiopulmonary arrest due to delayed recognition and delayed resuscitation [15]. The results indicate that provider education and simulation practice might have enhanced the providers' skills in recognizing the critical illness and reacting without unwarranted delay. Each of the indicators assessed for quality of chest compression was better during the re-audit. The percentage of correct compression rate rose from 54.2% to 84.4%, the percentage of correct compression depth rose from 49.0% to 79.2%, and the percentage of complete chest recoil rose from 53.1% to 81.3%. Interruption time was reduced to less than 10 seconds in 44.8% of the events, compared to 76.0% of the events [16]. These results were significant improvement, but not 100%, as adherence to these targets was not met with compression depth and minimisation of interruptions. This suggests that good CPR was still difficult to perform after education and reinforcement. Improvements were also great for following advanced PALS interventions. The rate of timely monitoring or defibrillator attachment rose from 61.5% to 88.5%, and correct rhythm identification rose from 64.6% to 89.6%. The ability to recognize and identify the rhythm accurately and quickly is critical as

it varies significantly for shockable versus non-shockable rhythms [17]. The monitor may not attach quickly, or the rhythm may be misinterpreted, delaying defibrillation, epinephrine, or other rhythm specific interventions. This improvement observed suggests that the preparation of equipment and targeted rhythm-recognition training may have been helpful parts of the quality-improvement effort. Assessment of reversible causes increased from 47.9% during the baseline audit to 80.2% during the re-audit. Since it is important to identify reversible causes, as resuscitation may be unsuccessful unless there is a cause such as hypoxia, hypovolemia, electrolyte disturbance, tension pneumothorax, cardiac tamponade, toxins, or thrombosis is recognised and treated [18,19]. Even with the significant enhancement, there was still an underrepresentation of reversible causes of almost 20% of re-audit events. This indicates that structured prompts/reminders using a checklist might be beneficial during a prolonged resuscitation or complex resuscitation. The clinical outcomes were generally favourable after the intervention [20]. The return of spontaneous circulation improved from 73.8% to 83.6% but this was not statistically significant. There was a significant improvement in survival to pediatric intensive care or definitive care transfer (69.8% to 82.3%) and to hospital discharge (46.9% to 59.4%), which was not statistically significant. There was no statistical significance for some outcomes which may have been attributed to differences in disease severity, factors other than resuscitation in the ED and sample size. However, it is likely that better adherence led to better short-term outcomes, as indicated by the direction of change. The audit was subject to several limitations. Some measures of adherence relied on medical records, and interventions that were not documented could have been deemed as not adherent to the intervention [21]. Not all the events could be witnessed directly and the quality of compressions could not have been objectively assessed without the use of feedback devices. The audit was undertaken at one institution only and may lack generalisability. Further, baseline and re-audit were different resuscitation events and differences in severity of illness may have affected results. There were also relatively few cardiac arrests, which made it difficult to identify differences in return of spontaneous circulation and survival. Despite these obstacles, the audit showed that a systematic quality improvement programme was linked to widespread improvement in initial assessment, CPR, advanced interventions, medication safety, teamwork and documentation.

CONCLUSION

There was a significant increase in adherence to PALS guidelines during emergency resus with targeted quality improvement measures, as demonstrated in the clinical audit. Early recognition, CPR quality, rhythm assessment, vascular access, medication administration, defibrillation, teamwork, documentation and post-resuscitation care showed significant improvements. Adherence score was significantly higher and the percentage of low adherence to resuscitation was lower. These improvements were supported by the presence of PALS certified team leaders, the use of structured simulation training, weight-based medication charts, clearly defined roles, closed loop communication with each other, organised resuscitation equipment and post-event debriefing.

Planned Re-Audit

Three to six months after the proposed quality-improvement measures are put into place, the re-audit will be done. In the re-audit period, a further 96 consecutive pediatric resuscitation cases will be reaudited in the Pediatric Emergency Department of Liaquat University Hospital, Hyderabad.

Recommendations and Action Plan

Deficiencies noticed during the baseline audit were addressed and a quality improvement plan was set into action to better follow the Pediatric Advanced Life Support (PALS) guidelines at Pediatric Emergency Department (PED) of Liaquat University Hospital, Hyderabad. The proposed measures were: staff training; cognitive aids available; organisation of resuscitation equipment; teamwork; documentation and post event learning.

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