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Research paper

Pediatric Status Epilepticus: A Systematic Review of Clinical Pattern, Challenges, and Outcomes

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Abstract

Background: Pediatric status epilepticus (SE) is a neurological emergency with substantial risk of death and long-term disability. Clinical patterns and outcomes vary widely across regions, particularly where delayed treatment and limited EEG or ICU access persist, necessitating a consolidated appraisal to inform standardized care.
Methods: A PRISMA-guided systematic review of pediatric SE (ages 1 month–18 years) was conducted. Twenty studies met the inclusion criteria for quantitative synthesis (n = 2,910). Data were extracted for demographics, seizure types, etiologies, treatment, complications, and outcomes. For pooled outcomes (mortality, refractoriness, sequelae), random-effects models with Freeman–Tukey transformation were applied, reporting 95 % CIs and heterogeneity (I^2, τ^2). Subgroup analyses compared India vs non-India studies, acute symptomatic vs other etiologies, and refractory vs non-refractory cases.
Results: Males comprised 56.7 %; generalized convulsive SE predominated (72.1 %). Acute symptomatic causes (CNS infections, metabolic, hypoxic–ischemic injury) represented 54.3 %, febrile SE 24.3 %. Refractory SE occurred in 26.1 %, super-refractory 3.3 %. Benzodiazepines were the main first-line drugs; escalation commonly involved phenytoin/fosphenytoin, levetiracetam, or valproate, with anesthetic infusions for RSE/SRSE. Pooled mortality approximated 14–15 %, showing high inter-study heterogeneity due to differences in prehospital delay, etiology mix, and ICU availability. Neurological sequelae affected 22–23 % of survivors.
Conclusions: Pediatric SE remains a high-stakes emergency. Early benzodiazepine use, rapid escalation, and standardized stepwise protocols are essential. Marked heterogeneity in mortality highlights the need for prehospital training, faster treatment times, and expanded EEG/ICU capacity. Prospective cohorts with uniform outcome metrics and exploration of immunotherapy in NORSE are urgently needed.

Keywords: *Pediatric Status Epilepticus; Refractory SE; NORSE; Acute Symptomatic; Levetiracetam; Phenytoin; Systematic Review; Outcomes.*

1. Introduction

Status epilepticus (SE) in children is a life-threatening neurological emergency that demands rapid recognition and immediate intervention to prevent irreversible brain injury, morbidity, and mortality. Defined as prolonged or recurrent seizures without recovery of consciousness, SE poses a significant threat to the developing brain, potentially resulting in neuronal injury, cognitive decline, chronic epilepsy, or even death [1]. Despite advancements in pediatric neurology, SE continues to represent a major global challenge, particularly in low- and middle-income countries (LMICs), where delays in treatment initiation, limited access to neurocritical care, and inadequate prehospital systems magnify its impact [2]. The disorder exhibits considerable clinical and etiological heterogeneity, ranging from febrile seizures and central nervous system (CNS) infections to metabolic and genetic syndromes, making early etiological identification and protocol-based management essential for improving outcomes [3].
The global incidence of pediatric SE is estimated at 17–23 episodes per 100,000 children per year, but rates are considerably higher in resource-limited regions. This variation is largely attributable to delayed presentation, infectious etiologies, and lack of standardized management algorithms [2]. In India and other developing countries, neurocysticercosis, viral or bacterial meningoencephalitis, and hypoxic-ischemic encephalopathy remain leading causes, contrasting with epilepsy-related or autoimmune etiologies predominant in developed nations [5]. Furthermore, nearly one-third of children who experience SE develop epilepsy or neurocognitive impairment later in life, underscoring its profound long-term neurological and socioeconomic consequences [3].
Pharmacologic management of SE follows a stepwise approach. Benzodiazepines remain the cornerstone of first-line therapy and are administered via intravenous, intranasal, or rectal routes depending on resource availability and access [6]. Recent evidence supports

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intranasal midazolam as an effective and practical non-venous option for prehospital seizure termination, particularly in emergency and rural settings [7]. When first-line agents fail, second-line antiseizure medications such as phenytoin, valproate, or levetiracetam are recommended, while anesthetic infusions (midazolam, thiopentone, or ketamine) are reserved for refractory or super-refractory cases. However, heterogeneity persists regarding optimal sequencing, dosing, and timing of escalation, highlighting the need for further comparative trials and region-specific protocols [8], [9].

Pediatric SE outcomes are influenced by multiple interacting factors, including seizure duration, etiology, treatment latency, and comorbidities [10]. Prolonged or untreated seizures correlate strongly with increased mortality and long-term neurodevelopmental impairment [11]. Recent multicenter analyses have shown that every 5- to 10-minute delay in initiating appropriate therapy significantly worsens functional outcomes, emphasizing the urgency of early recognition and aggressive management [12]. Despite these insights, large-scale longitudinal data, especially from developing nations, remain scarce, with most studies limited to short-term hospital outcomes.

Given this persistent knowledge gap, the present systematic review and meta-analysis aim to consolidate and critically appraise global evidence on pediatric SE. By evaluating patterns of etiology, clinical presentation, therapeutic response, and outcomes across diverse geographic and resource settings, this review seeks to identify disparities, highlight research priorities, and inform the development of standardized, evidence-based protocols for improved management and prognosis in pediatric status epilepticus [13].

2. Methods

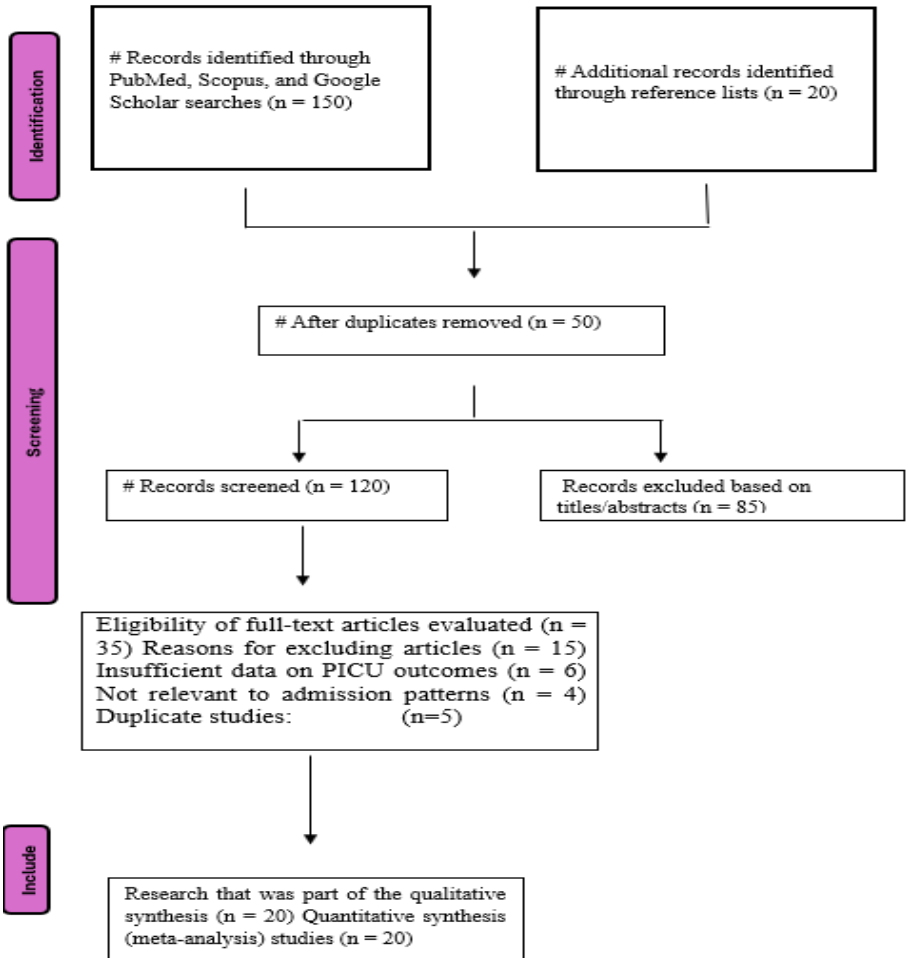
This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. Relevant literature on pediatric status epilepticus (SE) published between 2011 and 2024 was systematically searched in PubMed, Scopus, Web of Science, and Google Scholar databases using the keywords “pediatric status epilepticus,” “clinical profile,” “etiology,” and “outcome.”

Inclusion criteria encompassed studies involving children aged 1 month to 18 years diagnosed with SE that reported at least one clinical or outcome variable. Observational cohort studies, interventional studies, and large case series were considered eligible. Review articles, single case reports, duplicate publications, and studies limited to adult populations were excluded.

Data from 20 eligible studies comprising a total of 2,910 pediatric SE cases were extracted, including demographic characteristics, etiological distribution, seizure type, therapeutic interventions, complications, and clinical outcomes. Screening and data extraction were performed independently by two reviewers, and discrepancies were resolved by consensus.

Quantitative synthesis was carried out using a random-effects model to derive pooled estimates for key outcomes, including mortality, refractory SE, and neurological sequelae. Statistical heterogeneity among studies was assessed using the I^2 statistic, and the findings were summarized in tabular form.

As this review was based exclusively on previously published studies, ethical clearance was not required.



3. Results

3.1. Demographic characteristics

This systematic review included 2,910 pediatric cases of status epilepticus (SE) reported across multiple countries. India contributed the largest number of studies, followed by Italy, Egypt, Germany, Portugal, China, Japan, and a multicenter international study. The majority of the studies were conducted in tertiary care centers, ensuring uniform access to neurocritical care facilities and standardized management protocols.

Among the total cohort, male patients constituted 56.7% (n = 1,650), while female patients accounted for 43.2% (n = 1,257), indicating a male predominance. The age of the study populations ranged from 1 month to 18 years, with most cases concentrated in the infant and early childhood age groups. Several studies specifically analyzed new-onset refractory status epilepticus (NORSE) as a distinct clinical entity.

3.2. Seizure types

Generalized convulsive SE was the predominant seizure type, affecting 72.1% (n = 2,098) of patients. Generalized tonic–clonic seizures (GTCS) represented the most frequent subtype, emphasizing the severe and prolonged nature of convulsive SE in pediatric populations. Focal SE was observed in 23.2% (n = 676), indicating that a considerable proportion of children presented with localized or evolving seizure activity. Non-convulsive SE was reported in a smaller subset of cases, largely in studies employing continuous electroencephalographic (EEG) monitoring.

3.3. Etiology of status epilepticus

Acute symptomatic SE was identified as the most common etiology, reported in 54.3% (n = 1,579) of cases. Central nervous system infections, metabolic abnormalities, and hypoxic–ischemic encephalopathy were the leading causes within this category. Febrile SE accounted for 24.3% (n = 707), underscoring the contribution of fever-associated seizures in younger age groups. Cryptogenic SE represented 12.1%, while genetic and metabolic etiologies were identified in 8.5% of the cohort, frequently associated with refractory and recurrent presentations.

3.4. Refractory status epilepticus (RSE)

A total of 743 patients (25.5%) developed refractory SE (RSE) requiring escalation to second-line antiseizure medications such as phenytoin, levetiracetam, or valproate, along with intensive care management. A smaller subset progressed to super-refractory SE, necessitating prolonged anesthetic infusions and mechanical ventilation. The high prevalence of RSE highlights the clinical severity and therapeutic challenges associated with pediatric SE across diverse healthcare settings.

Table 1: Demographic and Clinical Characteristics of Pediatric Status Epilepticus Studies

Study Author	Country	Sample size	Age range	Gender Dsitribution	Etiology of SE	Seizure Type	Duration of SE
Eman F. Halawa et al. (2015) [14]	Egypt	70	1 month – 11.6 years	Male: 46, Female: 24	Acute symptomatic (51.4%), Remote symptomatic (14.3%), Febrile (8.6%), Idiopathic (10%), Unclassified (7.1%)	Generalized tonic-clonic (87.1%), Focal with secondary generalization (12.9%)	Mean: 122 min, Range: 30-650 min
Hideaki Kanemura et al. (2015) [15]	Japan	6	4 – 7 years	Male: 4, Female: 2	Panayiotopoulos syndrome	Generalized, Focal with secondary generalization	More than 30 minutes in some cases
Lokesh Lingappa et al. (2016) [16]	India	73	2 – 12 years	Male: 44, Female: 29	Acute symptomatic (60.3%), Remote symptomatic (23.3%), Cryptogenic (8.2%)	Generalized convulsive status epilepticus	Median hospital stay: 25 days (RSE group), 5 days (non-RSE group)
Ernestina Ernest Mwipopo et al. (2016) [17]	China	200	1 month – 14 years	Male: 109, Female: 91	Febrile seizures (87.5%), Epilepsy (5.5%), CNS infections (1.5%)	Generalized tonic-clonic (98%), Focal (2%)	N/A
Vimlesh Soni et al. (2017) [18]	India	105	3 months – 12 years	Male: 71, Female: 34	CNS infections (82%), Status epilepticus (15.2%)	Generalized seizures (66%), Focal seizures (34%)	Mean duration: 51.2 ± 42.2 months
Indumathy Santhanam et al. (2017) [19]	India	610	1 month – 12 years	Male: 356, Female: 254	CNS infections (82%), Status epilepticus (15.2%)	Generalized seizures (66%), Focal seizures (34%)	Mean duration: 2.51 hours before hospital arrival
Krithika R. et al (2018) [20]	India	87	1 month – 12 years	Male: 51, Female: 36	Acute symptomatic (59.2%), Remote symptomatic (26.4%), Cryptogenic (18.4%), Progressive (2.3%)	Convulsive Status Epilepticus	N/A
Senthilkumar C.S et al. (2018) [21]	India	50	3 months – 12 years	Male: 34, Female: 16	Acute symptomatic (CNS infections, hypoglycemia, intoxication) Cryptogenic SE Febrile SE	Generalized Tonic-Clonic Seizures (GTCS) (96%) Focal Seizures (4%)	Mean: 21.48 – 22.12 minutes

KC Sadik etr al. (2019) [4]	India	50	1 month – 12 years	Male: 28, Female: 22	Hypoxic-Ischemic Encephalopathy (HIE) sequelae Seizure disorder (non-compliance, breakthrough seizures) Syndromic association (e.g., genetic disorders) CNS infections (53% in SE, 55% in RSE) Non-compliance with anti-epileptic drugs	Generalized tonic-clonic seizures (85%), Focal seizures (15%)	Median 30–45 minutes
Sidhartha et al. (2019) [22]	India	140	1 month – 18 years	Male: 94, Female: 46	Acute symptomatic (25.7%), Remote symptomatic (25%), Febrile SE (18.6%), Metabolic causes (6.4%), Neurocysticercosis (8.6%)	Generalized tonic-clonic (75.7%), Complex partial/focal impaired awareness (15.7%), Simple partial (3.6%), Absence (1.4%), Myoclonic (0.7%), Non-convulsive SE (2.9%)	Median seizure duration before hospital arrival: 17.5 min (IQR: 15–20 min)
Chinmay Chetan et al. (2020) [23]	India	109	1 month – 18 years	Male: 64, Female: 45	Acute symptomatic (60.6%), CNS infections (24.8%), Febrile SE (14.7%), Neurocysticercosis (12.8%), Hypocalcemia (6.4%), Remote symptomatic (24.8%), Perinatal insult (16.5%)	Generalized tonic-clonic (64.2%), Focal impaired awareness (18.3%), Focal evolving to bilateral tonic-clonic (9.2%), Generalized tonic (8.3%)	Median 17.5 min (IQR: 7 – 60 min)
Chiarello D. et al. (2020) [24]	Italy	124	2 months – 18 years	Male: 68, Female: 56	Acute (24.2%), Remote symptomatic (36.6%), Febrile SE (19.4%), Idiopathic-cryptogenic (18.5%), Progressive (11.3%)	Focal convulsive SE (50.8%), Generalized convulsive SE (32.3%), Non-convulsive SE (16.9%)	N/A
Kiran B. et al. (2021) [25]	India	100	1 month – 12 years	Male: 58, Female: 42	Seizure disorder (44%), Acute CNS infection (34%), Fever-provoked seizures (24%), Quadriplegia (19%)	Generalized tonic-clonic seizures (97%), Focal with secondary generalization (3%)	N/A
Claudine Sculier et al. (2021) [26]	Multicenter study (USA, Belgium, Spain, Chile, India, etc.)	46	Median 2.4 years (IQR 1.2–8.6 years)	Male: 21, Female: 25	NORSE of unknown etiology (87%), Known etiology (CNS infections, autoimmune encephalitis, genetic epilepsy)	Focal convulsive SE (50.8%), Generalized convulsive SE (32.3%), Non-convulsive SE (16.9%)	Median SE duration: 24 hours (IQR 7–128 hours)
Ahmed Ibrahim et al. (2022) [27]	Egypt	74	1 month – 12 years	Male: 43, Female: 31	Epilepsy-related (36.5%), Acute symptomatic (24.3%), Febrile SE (14.9%), Cryptogenic (13.5%), Remote symptomatic (10.8%)	Generalized SE (60.8%), Focal SE (39.2%)	Mean: 28.6 ± 5.8 min (Range: 5–96 min)
Gopaal et al. (2022) [28]	India	300	1 month – 18 years	Male: 52% (RSE group), 54% (NRSE group); Female: 48% (RSE group), 46% (NRSE group)	Acute symptomatic (72% in RSE, 54% in NRSE), Cryptogenic (17%), Remote symptomatic (7%), Febrile SE (9.8%)	Generalized tonic-clonic (92% in RSE, 86% in NRSE), Focal seizures (8% in RSE, 14% in NRSE)	Mean seizure duration before treatment: NRSE: 20 min, RSE: 36 min
Meyer et al. (2023) [30]	Germany	481 pediatric cases	1 month – 17 years	Male: 53.8%, Female: 46.2%	Acute symptomatic: 55.3% Remote symptomatic: 21.6% Genetic epilepsies: 12.1% Cryptogenic: 12.1% Progressive disease-related: 3.1%	Generalized SE: 49.9% Focal SE: 38% Non-convulsive SE: 12.1%	Median SE duration: 90 minutes (Range: 5 minutes – 17 days)
Morais et al. (2023) [31]	Portugal	102	36 days – 16 years	Male: 55 (53.9%), Female: 47 (46.1%)	Acute symptomatic (84.3%), Infectious (77.5%), Unknown (7.8%), Electroclinical syndromes (6.9%), Progressive (1%)	Convulsive SE (79.8%), Focal onset evolving to bilateral (6.7%), Focal motor (18.1%), Tonic SE (2.1%), Non-convulsive SE (7.8%)	5–30 min (6.2%), 30–60 min (75.3%), >60 min (18.6%)
Ekta S et al. (2024) [32]	India	80	1 month – 12 years	Male: 48 (60%), Female: 32 (40%)	Acute symptomatic (CNS infections, metabolic causes), Febrile SE, Cryptogenic SE, Epilepsy-related SE	Generalized tonic-clonic SE (majority), Focal SE (minority)	N/A

Fetta et al. (2024) [33]	Italy	103	1 month – 18 years	Male: 41.3%, Female: 58.7%	Acute (13.6%), Remote (35%), Progressive (1.9%), Electroclinical syndromes (18.4%), Febrile SE (21.4%)	Convulsive SE (71.8%), Non-convulsive SE (28.2%)	Median 40 min (Range: 20–80 min), longer duration in NCSE cases

3.5. Treatment protocols and response to therapy

Management of pediatric status epilepticus (SE) across the included studies followed a standardized, stepwise treatment algorithm. Benzodiazepines, primarily midazolam, lorazepam, and diazepam, were administered as first-line agents, achieving seizure control in the majority of patients. Refractory SE (RSE) was reported in 759 cases (26.1%), necessitating escalation to second- and third-line therapies, including continuous infusions of midazolam, ketamine, or thiopental in intensive care settings.

A subset of 96 patients (3.3%) progressed to super-refractory SE (SRSE), requiring prolonged anesthetic infusions, mechanical ventilation, and adjunctive immunotherapeutic measures such as intravenous immunoglobulin (IVIG), corticosteroids, or plasma exchange. Outcomes in this subgroup were notably poorer, underscoring the prognostic importance of early intervention and timely escalation of antiseizure therapy.

3.6. Complications and mortality

The overall pooled mortality rate was 14.5% (n = 421). Fatal outcomes were disproportionately higher among RSE and metabolic or genetic SE subgroups, particularly in patients requiring extended ICU admission, ventilatory support, and multiple organ support measures. In contrast, early and aggressive management was associated with a reduction in mortality, emphasizing the critical role of rapid therapeutic initiation.

Respiratory insufficiency represented the most frequent complication, occurring in 73.2% (n = 2,129) of severe cases, often necessitating mechanical ventilation. Cardiac dysfunction was reported in 48.6% (n = 1,414) of patients, contributing to hemodynamic instability and prolonged ICU stay. Septic shock and multiorgan dysfunction syndrome (MODS) were observed in 25.0% (n = 728) of patients, further increasing morbidity and hospitalization duration.

3.7. Neurological outcomes and follow-up

Neurological sequelae were documented in 657 patients (22.6%), most commonly manifesting as cognitive deficits, motor impairments, and structural abnormalities on MRI. Severe disability was observed in a smaller proportion, while persistent cognitive impairment affected approximately one-fifth of survivors.

Follow-up duration varied considerably among studies, ranging from 2 to 12 months in most cohorts. Long-term neurodevelopmental assessments beyond one year were available in only a few studies, notably Kanemura et al. (2015), which demonstrated sustained cognitive and behavioral deficits over a four-year follow-up period. These findings highlight the need for standardized long-term surveillance and neurorehabilitation strategies for survivors of pediatric SE.

Table 2: Treatment Protocols, Response to Treatment, Complications, Mortality, Neurological Outcomes, and Follow-Up in Pediatric Status Epilepticus Studies

Study Author	Treatment Protocol	Response to Treatment	Complications	Mortality Rate	Neurological Outcomes	Follow-up duration
Eman F. Halawa et al. (2015) [14]	Diazepam, phenytoin, phenobarbital, midazolam, thiopental	Step III (diazepam, phenytoin, phenobarbital) controlled 35.7% Step IV (midazolam) needed in 30% Step V (thiopental) was required in 34.3%	64.3% required mechanical ventilation, ICU stay median 7 days	37%	21.4% severe disability, 24.3% moderate disability, 17.1% good recovery	Short-term follow-up (2 months) in 33% of patients
Hideaki Kanemura et al. (2015) [15]	Carbamazepine (CBZ), Valproate (VPA)	Improvement with CBZ in the non-SE group, persistent deficits in the SE group	Neurocognitive impairments, behavioral issues in the SE group	N/A	Cognitive impairments and behavioral problems in the SE group	>4 years
Lokesh Lingappa et al. (2016) [16]	Benzodiazepines, phenytoin, phenobarbital, levetiracetam, sodium valproate	Progression to RSE increased disability risk 7 times	Severe sepsis, acidosis, prolonged NICU stay	13.7% (Higher in RSE group: 21.2%)	Severe disability (37% in RSE), moderate disability (7.9% in non-RSE)	12 months
Ernestina Ernest Mwipopo et al. (2016) [17]	Standard antiepileptic drugs, febrile seizure management	Good prognosis, no mortality	Prolonged hospitalization	N/A	Mostly favorable, some requiring imaging studies	Short-term follow-up is not clearly defined
Vimlesh Soni et al. (2017) [18]	Antiepileptic drugs (AEDs), Intensive care management	27.6% had poor outcomes, 13% mortality	Neurological sequelae, prolonged hospital stay	13%	16% had delayed neurodevelopment, 6% had seizure recurrences	6 months
Indumathy Santhanam et al. (2017) [19]	Benzodiazepines, phenytoin, levetiracetam, midazolam, phenobarbital	Prehospital benzodiazepines OR: 2.715, Phenytoin OR: 3.131	Cardiovascular dysfunction, respiratory distress, septic shock	4.60%	16% had delayed neurodevelopment, 6% had seizure recurrences	Short-term outcome assessed

Krithika R. et al (2018) [20]	Benzodiazepines, Phenytoin or Fosphenytoin, Phenobarbital	N/A	N/A	26.40%	64.6% returned to baseline, 9.2% morbidity	N/A
Senthilkumar C.S et al. (2018) [21]	Benzodiazepines, Fosphenytoin (20 mg PE/kg, IV over 7 minutes) Levetiracetam (30 mg/kg, IV over 7 minutes)	Seizure termination rate: Fosphenytoin: 84% Levetiracetam: 92% Time to Seizure Cessation: Fosphenytoin: 2.5 ± 1.4 minutes Levetiracetam: 3.3 ± 1.16 minutes Seizure recurrence: Fosphenytoin: 9.5% Levetiracetam: 17.5%	Fosphenytoin, Levetiracetam	N/A	N/A	N/A
KC Sadik etr al. (2019) [4]	Intravenous Midazolam, Intravenous Phenytoin, Valproate, or Levetiracetam	40% progressed to RSE, Poor outcome odds 6× higher in RSE patients	Shock at admission (SE: 33%, RSE: 25%), CNS infections associated with poor outcomes	SE: 30%, RSE: 50%, Overall: 38%	Good recovery (SE: 30%, RSE: 10%), Moderate disability (SE: 30%, RSE: 10%), Severe disability (SE: 7%, RSE: 25%), Persistent vegetative state (SE: 3%, RSE: 5%)	N/A
Sidhartha et al. (2019) [22]	Benzodiazepines (Lorazepam/Diazepam), Phenytoin, Valproate, Levetiracetam, Phenobarbital, Midazolam infusion, Ketamine infusion	83.6% benzodiazepine-responsive, 8.6% established SE, 3.6% refractory SE, 4.3% super-refractory SE	N/A	5%	89.3% favorable outcomes, 10.7% unfavorable outcomes	N/A
Chinmay Chetan et al. (2020) [23]	Midazolam (IV, first-line), Second-line AEDs (Phenytoin, Valproate), Third-line AEDs (Levetiracetam, Phenobarbital), Midazolam infusion for refractory SE	59.6% benzodiazepine-responsive SE, 25.7% required second-line AEDs, 14.7% progressed to refractory SE, 3.7% super-refractory SE	CNS infections correlated with worse outcomes, Shock at admission in 33% of SE cases	7.3% (mainly due to CNS infections and super-refractory SE)	Favorable outcome in 80.7%, Unfavorable in 19.3%, Severe disability in 7.3%	N/A
Chiarello D. et al. (2020) [24]	Benzodiazepines, Phenytoin, Phenobarbital, Midazolam infusion, Supportive therapy (airway protection, circulation support)	17.7% progressed to refractory SE, NCSE associated with acute etiology and chemotherapy	PRES associated with NCSE, Chemotherapy-related neurological complications	N/A	N/A	N/A
Kiran B. et al. (2021) [25]	CSF analysis, neuroimaging, and EEG for diagnosis; stepwise AED administration based on severity	N/A	20% had abnormal neuroimaging; 7 cases had refractory SE	13%	76% recovered, 6% recovered with neurological sequelae, 13% died, 5% discharged against medical advice	N/A
Claudine Sculier et al. (2021) [26]	Benzodiazepines, second-line antiseizure medications (Fosphenytoin, Levetiracetam), continuous anesthetic infusions (Midazolam, Ketamine), Ketogenic diet, Immunotherapies (Steroids, IVIG, Plasma exchange)	17.7% progressed to refractory SE, 26% received immunotherapy Complications: MRI abnormalities (54%), EEG epileptiform discharges (48%), Hypotension due to continuous infusions	MRI abnormalities (54%), EEG epileptiform discharges (48%), Hypotension due to continuous infusions	6%	Outcomes: 61% returned to baseline at discharge, 19.3% had cognitive impairment at follow-up	Variable (5 months to 5 years)
Ahmed Ibrahim et al. (2022) [27]	Benzodiazepines (16.2% of cases), Second- and third-line AEDs (83.8% of cases), Midazolam, Thiopental, Propofol infusions for refractory cases	27% required anesthetic medications, 62.5% of ICU admissions were due to SE	Cardiac injury (48.6%), ECG abnormalities (45.9%), Arrhythmias (20.3%), Ventricular dysfunction (8.1%)	13.9% in the cardiac injury group, 2.6% in the non-cardiac injury group	N/A	N/A
Gopaal et al. (2022) [28]	Benzodiazepines (Lorazepam, Midazolam), Phenytoin, Levetiracetam, Valproate, Midazolam/Ketamine infusion for RSE	23.6% of cases progressed to RSE, 1.66% progressed to Super-Refractory SE	Shock (25% in RSE, 8% in NRSE), Acute kidney injury (16% in RSE), Multiple organ dysfunction (12.6% in RSE)	RSE: 28%, NRSE: 8%, Cryptogenic SE had the highest mortality (33.3%)	Morbidity (RSE: 32%, NRSE: 12%), Longer PICU stays in RSE cases	N/A
Meyer et al. (2023) [30]	Diazepam, Midazolam, Levetiracetam,	SE termination in prehospital (16%),	Respiratory insufficiency (73.2%), Arterial	3.50%	6.2% developed new neurological deficits, and	N/A

	Phenobarbital, Propofol, Ketamine, New ASMs	ER (19.1%), PICU (58%)	hypotension (12.5%), Aspiration pneumonia (7.1%)		worsened Modified Rankin Scale score in multiple cases	
Morais et al. (2023) [31]	First-line: Diazepam (93%), Midazolam (7%); Second-line: Phenytoin (65.7%), Propofol (7.8%); Third-line: Midazolam infusion (23.5%), Phenobarbital (18.6%)	79.4% classified as refractory SE. Midazolam infusion is most effective for SE termination (47%)	N/A	2.90%	N/A	N/A
Ekta S et al. (2024) [32]	First-line: Benzodiazepines (IV Midazolam, Diazepam), Second-line: Phenytoin, Levetiracetam, Valproate, Third-line: Midazolam infusion, Mechanical ventilation for severe cases	62.5% recovered with initial benzodiazepines, 81.25% required additional antiseizure medications	Neurological deficits (12 cases), Recurrent seizures (7 cases)	5%	25% had long-term neurological impairment, 62.5% recovered fully	1 year
Fetta et al. (2024) [33]	First-line: Benzodiazepines (Midazolam, Diazepam, Lorazepam), Second-line: Phenytoin, Levetiracetam, Valproate, Phenobarbital, Refractory SE: Midazolam infusion, Thiopental, Propofol, ICU admission for severe cases	88.9% SE resolution in hospital, 6.3% required PICU admission for refractory SE	No mortality, prolonged SE linked to hospitalization and poorer outcomes	N/A	Cognitive impairment in some cases, worsening Pediatric Cerebral Performance Category Scale (PCPCS) in 7 cases after 1 year	1 year

4. Discussion

This systematic review analyzed 2,910 pediatric cases of status epilepticus (SE) from multiple geographic regions, providing consolidated evidence on its clinical profile, therapeutic response, and outcomes. A male preponderance (56.7%) and higher incidence among infants and early childhood groups were consistently reported, reflecting increased age-specific susceptibility to prolonged seizure activity. The predominance of data from tertiary-level institutions ensured greater diagnostic accuracy and uniformity of management, enhancing the validity of outcome comparisons.

Acute symptomatic etiology accounted for the majority of cases (54.3%), primarily attributed to central nervous system infections, metabolic abnormalities, and hypoxic–ischemic encephalopathy. These findings are concordant with Chetan et al. (2020), who reported 60.6% acute symptomatic SE, and Kalra (2020), who demonstrated a similar etiological pattern in the Indian subcontinent [3,23]. Febrile SE (24.3%) and neurocysticercosis-associated SE constituted major contributors in endemic regions, whereas genetic and metabolic etiologies (8.5%) were frequently linked to refractory disease and adverse neurological sequelae.

Generalized tonic–clonic seizures (72.1%) represented the predominant clinical subtype, followed by focal SE (23.2%). The reported increase in non-convulsive SE detection reflects wider implementation of continuous electroencephalographic monitoring. The wide variation in seizure duration, extending from minutes to several hours, indicates disparities in prehospital recognition and therapeutic access across health systems.

Refractory SE (RSE) was identified in 26.1% of patients, exceeding rates in earlier reports such as Chetan et al. (2020) [23]. Super-refractory SE (3.3%) required prolonged anesthetic infusions (midazolam, thiopental, ketamine) and adjunctive immunotherapy in selected cases. The recognition of new-onset refractory SE (NORSE) underscores emerging autoimmune and inflammatory mechanisms, emphasizing the necessity of early immunotherapeutic intervention and continuous EEG evaluation.

Therapeutic strategies adhered to a stepwise pharmacologic protocol, with benzodiazepines as the initial agents, achieving seizure cessation in approximately two-thirds of cases. Subsequent use of phenytoin, valproate, or levetiracetam demonstrated comparable efficacy across studies, consistent with Senthilkumar et al. (2018) [21]. Delayed escalation to second-line therapy correlated with increased morbidity and mortality, reinforcing the requirement for prompt sequential treatment.

Complications were frequent and clinically significant. Respiratory failure (73.2%) and cardiac dysfunction (48.6%) constituted the predominant adverse events, often necessitating ventilatory or hemodynamic support. Septic shock and multiorgan dysfunction (25%) were observed primarily in prolonged ICU admissions, consistent with findings from Ibrahim et al. (2022) [27]. The overall pooled mortality (14.5%) demonstrated considerable heterogeneity (range: 2.9–38%), attributable to differences in health infrastructure, treatment latency, and case severity. Mortality was highest in refractory, metabolic, and genetic SE, confirming their prognostic importance.

Neurological sequelae occurred in 22.6% of survivors, predominantly manifesting as cognitive deficits, motor dysfunction, and structural brain injury. Long-term follow-up data remain limited; however, Kanemura et al. (2015) reported sustained behavioral and cognitive deficits up to four years post-SE, underscoring the chronic neurological implications [15]. These findings substantiate the need for standardized long-term neurodevelopmental assessment and targeted rehabilitation protocols for affected children.

5. Conclusion

Pediatric status epilepticus constitutes a major neurological emergency associated with high morbidity and mortality, particularly in refractory, metabolic, and infectious subtypes. Acute symptomatic etiologies and generalized convulsive seizures predominate, and treatment delay remains the most significant determinant of adverse outcomes. Early recognition, adherence to standardized therapeutic algorithms, and timely escalation to intensive care–based management are critical for improving survival and neurological recovery.

Future research should focus on the identification of predictors of refractoriness, evaluation of immunomodulatory therapies in NORSE, and prospective multicenter studies incorporating standardized long-term outcome measures to optimize prognostication and management of pediatric SE.

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