

Aspiration Risk Assessment in Alcohol-intoxicated Mild Traumatic Brain Injury Patients: A Prospective Cross-sectional Study using the Simple Swallowing Assessment

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ABSTRACT

Introduction: Mild Traumatic Brain Injury (TBI) is prevalent in Emergency Departments, yet the aspiration risk in alcohol-intoxicated patients remains understudied. Aspiration can precipitate life-threatening pneumonia, particularly in patients with impaired protective reflexes.

Aim: To determine the prevalence of aspiration risk and identify clinical predictors in alcohol-intoxicated mild TBI patients using the Simple Swallowing Assessment (SSA) in a tertiary care Emergency Department.

Materials and Methods: A prospective cross-sectional study was conducted over 18 months from January 2022 to June 2023 in the Emergency Department, Krishna Institute of Medical Sciences, Krishna Vishwa Vidyapeeth, Karad, Maharashtra, India. A total of 250 patients with TBI were screened; 187 patients with mild TBI {Glasgow Coma Scale (GCS): 13-15} and confirmed alcohol intoxication {Blood Alcohol Concentration (BAC) $\geq 0.08\%$ } were included. Aspiration risk was assessed using the SSA. Demographic characteristics, injury mechanism,

BAC, and clinical outcomes were recorded. Statistical analysis included descriptive statistics, Chi-square tests for categorical associations, and logistic regression to identify independent predictors. Statistical significance was set at $p < 0.05$. Statistical Package of Social Sciences (SPSS) version 25.0 was used.

Results: The mean age of the patients was 35.4 ± 10.2 with 134 males. Overall aspiration prevalence was 15.7% {95% Confidence Interval (CI), 11.2%-20.2%}. Age > 40 years {Odds Ratio (OR) 2.1, 95% CI 1.3-3.4}, BAC > 150 mg/dL (OR 1.8, 95% CI 1.1-2.9), and Road Traffic Accidents (RTA) (OR 1.6, 95% CI 1.0-2.5) emerged as independent risk factors. Patients with aspiration signs developed pneumonia within 72 hours more frequently ($p = 0.01$) and had longer hospital stays (mean 7 days vs. 4 days, p -value = 0.03).

Conclusion: Aspiration is a clinically significant finding in alcohol-intoxicated mild TBI patients, particularly in older adults and those with high blood alcohol levels. Early identification using bedside screening tools such as the SSA enables timely intervention and improves patient outcomes.

Keywords: Blood alcohol intoxication, Dysphagia, Pneumonia

INTRODUCTION

The TBI stands as a leading cause of mortality and morbidity with a global estimate of 69 million individuals annually [1]. Mild TBI constitutes approximately 80% of all TBIs presenting to Emergency Departments [2]. Though it is a common presentation, mild TBI frequently results in some neurological impairment and multi-system complications including aspiration risk [3].

Aspiration is the unintentional entry of food, liquid, or secretions into the airway below the level of vocal cords which is a serious complication [4], in patients with altered sensorium or impaired swallowing function. In TBI populations, aspiration occurs as a consequence of depressed consciousness, impaired airway protective reflexes (cough, gag), and decreased pharyngeal muscle tone. Aspiration pneumonia is the leading infectious cause of mortality in TBI patients who are hospitalised, occurring in 11-37% depending on severity. This morbidity burden explains the clinical importance of early identification and intervention.

Alcohol intoxication increases the aspiration risk in patients who sustain trauma through multiple mechanisms. Ethanol has depressive effects on the central nervous system, reducing protective airway reflexes [5], muscular coordination, and impairs swallowing. The synergistic effect of TBI and alcohol intoxication is a common clinical

scenario in emergency trauma population, creating a particularly high-risk situation for aspiration and respiratory complications [5]. In regions with high alcohol consumption and high-incidence trauma patterns (such as Maharashtra, India) [6], this population deserves specific epidemiological characterisation.

On top of these recognised risks, the published epidemiological data on quantifying aspiration prevalence and identifying clinical predictors in alcohol-intoxicated mild TBI patients are limited. Most of the previous studies have focused on severe TBI [7], mechanically ventilated populations, or heterogeneous cohorts without stratification by injury severity or intoxication status. This knowledge gap limits the development of evidence-based screening and intervention protocols tailored to this specific, common, and at-risk population in resource-limited settings.

The SSA [8], is a validated, rapid bedside screening tool suitable for Emergency Department use. The SSA demonstrates good sensitivity and specificity [9], for identifying aspiration risk without requiring specialised equipment or extended assessment time. Early use of the SSA to detect aspiration risk in alcohol-intoxicated patients with mild TBI was expected to show that aspiration is fairly common in this group and to highlight changeable risk factors that could be addressed with focused interventions.

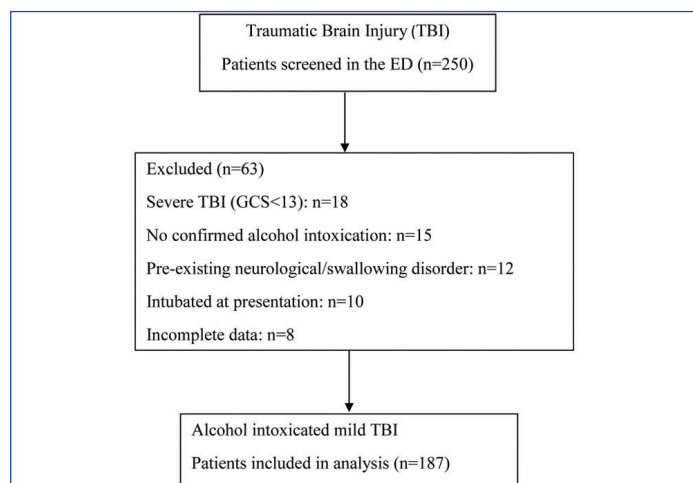
The present study, conducted as a prospective cross-sectional analysis, set to measure how common aspiration is among alcohol-intoxicated patients with mild TBI, to point out key clinical risk factors, and track early issues like pneumonia and longer hospital stays. The results are meant to shape Emergency Department protocols and support public health efforts tackling trauma and alcohol problems in low resource areas. The present study aimed to determine the prevalence of aspiration risk and identify clinical predictors in alcohol-intoxicated mild TBI patients using the SSA in a tertiary care Emergency Department.

The primary objective of present study was to estimate the prevalence of aspiration risk, as identified by a positive SSA, in patients with mild TBI and acute alcohol intoxication. The secondary objectives were to evaluate the association between demographic factors such as age and gender and aspiration risk, to determine the relationship between BAC levels and the likelihood of aspiration, to examine the association between mechanism of injury (including RTAs, falls, and assaults) and aspiration risk, to identify independent predictors of aspiration using multivariate logistic regression analysis, and to assess early clinical outcomes, which include developing pneumonia and length of hospital stay, in patients with and without aspiration signs.

MATERIALS AND METHODS

A prospective cross-sectional study was conducted in the Department of Emergency Medicine, Krishna Institute of Medical Sciences, Krishna Vishwa Vidyapeeth, Karad, Maharashtra, India over 18 months from January 2022 to June 2023. The Institutional Ethics Committee of Krishna Hospital approved the study (approval number KW/IEC/08/2023; protocol 667/2022-2023). Written informed consent was obtained from all participants or their legally authorised representatives before enrolment to the study. The study adhered strictly to the Declaration of Helsinki (2013) and ensured confidentiality of study participants [10]. A total of 250 patients with TBI presenting to the Emergency Department were initially screened.

Sample size calculation: The required sample size was calculated using the formula $n = Z^2 \times p \times (1-p) / e^2$, where $Z = 1.96$ (95% confidence level), $p = 0.157$ (estimated aspiration prevalence i.e., 15.7%), and $e = 0.05$ (margin of error), giving $n = 1.96 \times 1.96 \times 0.157 \times 0.843 / 0.05 \times 0.05 \approx 202.7$, which was rounded to 203 participants. The estimated prevalence of 15.7% was derived [11,12] from previously published studies reporting aspiration pneumonia incidence rates between 14% and 18% among TBI patients, including those with alcohol intoxication. After accounting for potential dropouts, 187 patients completed the study and met all inclusion criteria. Although the calculated sample size was 203, recruitment ended at 187 eligible patients at the end of the predefined 18-month study period; this achieved sample still provided adequate precision for the primary prevalence estimate and stable estimates in the multivariable model. [Table/Fig-1] shows the screening and inclusion process for the study cohort.



[Table/Fig-1]: Screening and inclusion of alcohol-intoxicated mild TBI patients.

Inclusion criteria: Adult patients (≥ 18 years) with mild TBI, defined by a GCS score of 13-15, were included in the study [1]. Patients with confirmed acute alcohol intoxication, defined as a BAC $\geq 0.08\%$ (80 mg/dL) on breath analysis, were also eligible for enrolment, consistent with widely accepted legal and clinical thresholds for intoxication. All participants presented to the Emergency Department within four hours of injury and were enrolled consecutively.

Exclusion criteria: Patients were excluded if they had severe TBI (GCS < 13), pre-existing swallowing or neurological disorders (stroke, Parkinson's disease, myasthenia gravis), who were intubated or mechanically ventilated at presentation, lacked confirmed alcohol intoxication, were younger than 18 years, or had incomplete data.

Study Procedure

Assessment of alcohol intoxication: The BAC was measured using a portable breath alcohol analyser (True Sense AT-002 Portable Digital Breath Alcohol Tester) within 30 minutes of presentation. Patients with BAC $\geq 0.08\%$ (80 mg/dL) were classified as alcohol-intoxicated, consistent with legal definitions of impairment in most jurisdictions [5].

Simple Swallowing Assessment (SSA) Procedure: Upon arrival, trained emergency physicians conducted the SSA [11,13], as part of the initial assessment, typically within one hour of admission as follows. Oral administration of 5 mL of room-temperature water, careful observation for immediate clinical signs including coughing, choking, voice change (hoarseness or wet voice quality), or audible aspiration, and documentation of the presence or absence of these signs. Any such sign considered as positive SSA result which indicates aspiration risk. The assessment was conducted before any oral intake other than the SSA itself.

Data collection: Structured case report forms were used to systematically record: a) demographics (age, gender); b) injury mechanism (RTAs, fall, assault); c) GCS score at presentation; d) BAC in mg/dL; e) SSA result (positive/negative); f) time from injury to SSA assessment; g) early outcomes including pneumonia development within 72 hours (defined as new infiltrate on chest imaging plus clinical signs) and total length of hospital stay. Data quality was ensured through regular checks for completeness and consistency.

STATISTICAL ANALYSIS

Descriptive statistics summarised demographic and clinical characteristics using means {Standard Deviation (SD)} for continuous variables and frequencies (percentages) for categorical variables. Continuous variables with approximately symmetric distributions were summarised as mean and SD, whereas skewed variables, such as time from injury to SSA, were summarised as median and Interquartile Range (IQR). The primary outcome, prevalence of aspiration was expressed with 95% CIs. Univariate analysis like Chi-square or exact tests were used for comparisons of categorical variables, as appropriate. Multivariate logistic regression analysis was performed to identify independent predictors of aspiration, adjusting for potential confounders (age, gender, injury mechanism, BAC level). The model included terms for age > 40 years (binary), BAC > 150 mg/dL (binary), and injury mechanism (categorical). Results are presented as Odds Ratio (OR) with 95% CIs. All statistical analyses were conducted using SPSS software (version 25; IBM, Armonk, NY, USA). Statistical significance was defined as $p < 0.05$.

RESULTS

Demographic and clinical characteristics are summarised in [Table/Fig-2] and show that the study cohort consisted predominantly of young to middle-aged males injured mainly in RTAs, with generally preserved consciousness at presentation. Approximately, half of the

Variables	Values
Age (years) (Mean±SD)	35.4±10.2
Gender	
Male n (%)	134 (71.7)
Female n (%)	53 (28.3)
Glasgow Coma Scale (GCS) score at presentation (Mean±SD)	14.2 (0.8)
Injury mechanism n (%)	
Road Traffic Accident (RTA)	121 (64.7)
Fall	47 (25.1)
Assault	19 (10.2)
BAC (mg/dL) (Mean±SD)	158±74
BAC n (%)	98 (52.4)

[Table/Fig-2]: Demographic and clinical characteristics of alcohol-intoxicated mild TBI patients (N=187).

patients had high blood alcohol levels and the SSA was performed relatively early after injury, supporting the relevance of the aspiration risk assessment to the acute phase of care.

Prevalence of Aspiration

The overall prevalence of aspiration, identified by positive SSA, was 15.7% (95% CI, 11.2%-20.2%; n=29 of 187). This represents approximately one in six patients with alcohol-intoxicated mild TBI demonstrating objective signs of aspiration risk. The distribution of aspiration status is presented in the [Table/Fig-3].

SSA outcome	n (%)	95% CI
SSA positive (aspiration risk)	29 (15.7)	11.2-20.2
SSA negative	158 (84.3)	-
Total	187 (100)	-

[Table/Fig-3]: Prevalence of aspiration risk based on SSA.

Age as a Risk Factor for Aspiration

Patients older than 40 years had a significantly higher proportion of aspiration compared with those aged 18-40 years (28.8% vs. 10.4%), and age >40 years remained an independent predictor of aspiration in the multivariable model.

Blood Alcohol Concentration (BAC) as a Risk Factor

Patients with higher blood alcohol concentration were more likely to aspirate than those with lower levels, and a BAC ≥150 mg/dL was independently associated with increased aspiration risk on logistic regression. The distribution of aspiration risk across age, sex, blood alcohol concentration, and injury mechanism are summarised in [Table/Fig-4].

Variables	Category	Aspiration present n (%)	Aspiration absent n (%)	p-value
Age group	18-40 years	14 (10.4)	121 (89.6)	0.02
	>40 years	15 (28.8)	37 (71.2)	
Gender	Male	21 (15.7)	113 (84.3)	0.89
	Female	8 (15.1)	45 (84.9)	
BAC category	<150 mg/dL	10 (11.2)	79 (88.8)	0.04
	≥150 mg/dL	19 (19.4)	79 (80.6)	
Injury mechanism	RTAs	21 (17.4)	100 (82.6)	0.29
	Fall	6 (12.8)	41 (87.2)	
	Assault	2 (10.5)	17 (89.5)	

[Table/Fig-4]: Aspiration risk across demographic and clinical sub-group.

Injury Mechanism as a Risk Factor

Injury mechanism showed higher aspiration risk among patients injured in RTAs compared with those with falls or assaults. This did not reach statistical significance. In multivariable analysis, RTAs remained a borderline predictor of aspiration after adjustment for

age and BAC, suggesting that more severe multisystem trauma may contribute to increased aspiration vulnerability in this group.

Sex was not associated with aspiration risk, and no other demographic variables showed significant relationships with aspiration in this cohort.

Patients with positive SSA results experienced markedly worse early clinical outcomes, including a substantially higher rate of pneumonia within 72 hours and longer hospital stays compared with those without aspiration signs. These outcome differences are summarised in [Table/Fig-5].

Variables	Aspiration present (n=29)	Aspiration absent (n=158)	p-value
Time from injury to SSA	2.0 (1-3)	2.0 (1-4)	0.62
Pneumonia within 72 hours, n (%)	17 (58.6)	8 (5.1)	<0.001
Hospital length of stay (days), mean (SD)	7.1 (3.2)	4.2 (2.1)	0.03

[Table/Fig-5]: Timing of SSA and early clinical outcomes by aspiration status (N=187).

Time from injury to SSA is expressed as median (IQR)

Summary of Independent Risk Factors

In multivariate logistic regression, age >40 years and BAC ≥150 mg/dL remained significant independent predictors of aspiration, while RTAs showed a borderline association with increased aspiration risk after adjustment for other covariates. The multivariate model has been depicted detailed in [Table/Fig-6].

Predictor	Adjusted OR	95% CI	p-value
Age >40 years	2.1	1.3-3.4	0.01
BAC >150 mg/dL	1.8	1.1-2.9	0.03
RTAs (vs others)	1.6	1.0-2.5	0.06
Gender (male vs female)	1.0	0.5-2.0	0.98

[Table/Fig-6]: Multivariate logistic regression for independent predictors of aspiration

The regression model was stable, with no evidence of multicollinearity among predictors.

DISCUSSION

The present prospective cross-sectional study measured aspiration risk in the alcohol-intoxicated patients with mild TBI, a group that has been understudied. The findings reveal important epidemiological and clinical insights relevant to emergency care and public health strategies in settings with limited resources.

Prevalence and comparative epidemiology: In present study, the prevalence of aspiration was 15.7%, meaning that about one in six alcohol-intoxicated patients with mild TBI showed signs of unsafe swallowing on the SSA. This frequency is comparable to the incidence of aspiration pneumonia reported in previous work on TBI, which has generally ranged around 14-18% in mixed-severity TBI cohorts [11,12]. Because the present study focused only on patients with mild TBI, it adds evidence that clinically important aspiration risk is not limited to severe injuries and should also be considered in less severe head trauma with attention.

The relatively high prevalence observed in an alcohol-intoxicated population also supports the concept that alcohol is an important modifier of swallowing safety and may increase aspiration risk beyond that seen in non-intoxicated TBI or general trauma groups. Direct comparative studies were not performed here.

Age as an independent risk factor: Age >40 years emerged as the strongest independent predictor of aspiration in our cohort, with approximately doubled odds (OR 2.1, 95% CI 1.3-3.4). This finding is consistent with extensive dysphagia literature documenting presbyphagia [14-16], an age-related decline in swallowing physiology characterised by weakened pharyngeal musculature, delayed swallow onset, and reduced laryngeal protection. Older

adults demonstrate reduced sensorimotor function [16] in swallowing and are more susceptible to aspiration consequences including pneumonia and prolonged recovery [17,18]. In cases of combined neurological injury from TBI and central nervous system depression due to alcohol intoxication, this age related physiological weaknesses become clinically apparent. The age threshold of 40 years identified in present data aligns with prior studies demonstrating increased aspiration and complications in older trauma populations.

Blood Alcohol Concentration (BAC) as an independent predictor:

Higher BAC (>150 mg/dL) was independently associated with 1.8 times greater odds of aspiration (95% CI 1.1-2.9, $p=0.03$). This finding supports existing evidence that alcohol weakens the reflexes that protect the airway [5]. Alcohol induced depression of consciousness, weaker cough and gag reflexes, impaired muscle coordination, and altered swallowing mechanics together increase the likelihood of aspiration [19,20]. The threshold of 150 mg/dL identified in our analysis represents moderate to high intoxication levels and may represent a critical point at which CNS depression significantly impacts protective mechanisms. Previous studies have shown dose-dependent links between alcohol intake and aspiration risk in general populations [19], although detailed measurements in TBI patients remain limited.

Injury mechanism and trauma severity: RTAs demonstrated borderline independent association with increased aspiration risk (OR 1.6, 95% CI 1.0-2.5, $p=0.06$). This finding likely reflects the greater severity of multisystem trauma, increased neurotrauma severity, and potentially more profound initial consciousness impairment associated with RTA mechanisms compared to lower-energy mechanisms such as falls or assaults. RTA victims frequently sustain polytrauma affecting multiple organ systems, potentially resulting in more substantial neurological impact and greater physiological disruption. Although this association was not statistically significant, its direction and size make clinical sense and agree with reports from injury severity studies.

Clinical Utility of Simple Swallowing Assessment (SSA): The SSA proved to be a rapid, practical bedside screening tool suitable for Emergency Department implementation [21]. No specialised equipment beyond a cup of water is required, assessment requires less than five minutes, and trained emergency physicians can reliably perform the test within the first hour of admission. The strong association between positive SSA results and subsequent pneumonia development (58.6% vs. 5.1%, $p<0.001$) validates the clinical meaningfulness of SSA-identified aspiration risk [11,12]. These findings support integration of SSA into standard trauma and TBI protocols, particularly in resource limited settings where advanced diagnostic modalities (endoscopic swallowing studies, video fluoroscopy) may be unavailable or impractical.

Early clinical consequences: Patients with aspiration signs demonstrated significantly higher rates of pneumonia development within 72 hours (58.6% vs. 5.1%, $p<0.001$) and prolonged hospital stays (mean 7.1 vs. 4.2 days, $p=0.03$). These outcomes underscore the clinical importance of early identification. Although current design does not permit causal inference, the strong temporal and statistical associations suggest that aspiration identification provides prognostic information and potentially identifies patients benefiting from protective interventions (head-of-bed elevation, cautious oral intake initiation, swallowing therapy referral). The 72-hour pneumonia observation window captures the most common timing of aspiration-related pneumonia in acute TBI populations.

Distinction between aspiration risk and clinical pneumonia:

The study appropriately distinguishes between aspiration risk (SSA positivity) and confirmed clinical outcomes. Positive SSA indicates physiological aspiration risk but does not diagnose aspiration pneumonia. However, the strong correlation observed (58.6% pneumonia rate in SSA-positive patients) validates SSA as a predictive tool. Not all aspiration results in pneumonia, as bacterial

colonisation [22], immune status, and other factors modulate progression. Still, a positive SSA result identified a clearly higher-risk group that needs closer monitoring and preventive measures.

Public Health and Implementation considerations: The findings support integration of standardised aspiration screening into trauma protocols in similar epidemiological and resource settings. In Maharashtra and comparable regions with high alcohol consumption [6,20] and high-incidence trauma patterns, early SSA-based identification enables targeted interventions for high-risk patients, potentially reducing morbidity and mortality. Recommended protective measures [23], in SSA-positive patients include: nil-per-os status pending swallowing therapy evaluation; semi-upright positioning ($\geq 30^\circ$) to facilitate safe swallowing mechanics; close respiratory monitoring; early swallowing therapy referral when available; preferential nasogastric feeding if prolonged oral intake restriction is necessary. Implementation of such protocols in emergency settings requires minimal additional resource investment and may substantially impact patient outcomes.

Limitation(s)

The present study was a single centre study conducted at one tertiary care hospital in Maharashtra, potentially limiting generalisability to other geographic regions with different epidemiology, healthcare infrastructure, or alcohol consumption patterns. Patients with severe TBI (GCS <13) were deliberately excluded, restricting applicability to the mild TBI population specifically; findings may not be applicable to severe TBI where aspiration risk and complications are considerably higher. The sample size, though adequate for primary analyses, may have limited statistical power for certain subgroup assessments, as evidenced by the borderline significance of RTAs factor association. The study design is observational and cross-sectional, permitting identification of associations but not causal determination; randomised trials comparing SSA-directed versus standard care would be needed to establish causality and intervention efficacy. The follow-up was limited to 72 hours for pneumonia assessment; long term outcomes and complications were not captured. The SSA, while practical, has lower sensitivity and specificity for subtle aspiration compared to video fluoroscopy or fibreoptic endoscopic evaluation; a small proportion of aspiration cases may have been missed. Finally, all patients were alcohol-intoxicated at presentation, limiting applicability to non-intoxicated TBI populations.

Despite these limitations, the study provides valuable epidemiological and clinical insights into an understudied, clinically important population. Prospective multicentre studies incorporating larger cohorts across diverse geographic regions, longer follow-up durations, and comparison with advanced swallowing assessment modalities are warranted to validate findings, explore causal mechanisms, and optimise evidence-based management strategies.

CONCLUSION(S)

The present study found aspiration risk in about one in six drunk patients with mild head injuries. Key factors were age over 40, high alcohol levels above 150 mg/dL, and road accidents. The quick SSA worked well, as positive tests matched early pneumonia cases. Spotting this risk early with SSA lets doctors act fast to stop lung issues in these patients. Adding this simple check to regular trauma care could help a lot, especially in busy places with lots of alcohol-related injuries and few resources. More studies across hospitals, with bigger groups and longer follow-up, are needed to back this up and fine-tune care.

Acknowledgement

The authors would like to express their sincere gratitude and extend their appreciation to all the staff members and colleagues who provided technical assistance and support throughout present study. Authors are especially thankful to the patients and

their families for participating in present research, enabling them to gather valuable data. No external funding supported this work, and all opinions expressed are those of the authors. Lastly, authors thank the anonymous reviewers and editorial staff for their valuable feedback, which enhanced the quality of this manuscript.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: Nov 24, 2025
- Manual Googling: Dec 24, 2025
- iThenticate Software: Dec 27, 2025 (3%)

ETYMOLOGY: Author Origin

EMENDATIONS: 7

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Nov 23, 2025**

Date of Peer Review: **Dec 15, 2025**

Date of Acceptance: **Dec 30, 2025**

Date of Publishing: **Jun 01, 2026**