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Clinical interpretability of serum acetaminophen concentrations in emergency poisoning care: a retrospective Poison Center study

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Clinical interpretability of serum acetaminophen concentrations in emergency poisoning care: a retrospective Poison Center study

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Abstract

Background: Serum acetaminophen concentration is an important tool for risk stratification after acute poisoning, but cannot be reliably interpreted using the Rumack–Matthew nomogram without accurate temporal information. Structured documentation of ingestion and blood collection times may represent a simple systems-level intervention to improve toxicological risk assessment in emergency settings. We evaluated the clinical interpretability of serum acetaminophen concentrations in real-world poisoning cases managed through a Brazilian Poison Information Center, with particular emphasis on cases with sufficient concentration and temporal data for descriptive nomogram-based risk assessment. **Methods:** This retrospective descriptive study included 295 acetaminophen poisoning cases referred to the Toxicological Information Center of Rio Grande do Sul (CIT-RS), Brazil, for serum acetaminophen quantification between January 2023 and December 2025. Demographic, clinical, toxicological, laboratory, and treatment data were extracted from institutional records. Serum acetaminophen was quantified using a previously validated spectrophotometric method. The relationships between self-reported ingested dose, sampling time, and serum concentration were explored using Spearman's correlation and multiple linear regression. Cases with quantifiable concentrations and documented sampling times were assessed using the Rumack–Matthew nomogram. **Results:** Females accounted for 63.4% of cases, the median age was 22 years, and intentional self-poisoning accounted for 78.3%. Co-ingestion of other substances was documented in 58.3% of cases. Serum acetaminophen quantification was requested in 295 of 4,331 acetaminophen-related cases managed by CIT-RS (6.8%). Concentrations were below the lower limit of quantification in 54.9% of cases. Blood sampling time was unavailable in 157 cases (53.2%), substantially limiting systematic interpretation of serum concentrations. Among 55 cases with quantifiable concentrations, documented timing

within the 4–24-h nomogram window, and sufficient information for risk assessment, 23 (41.8%) were above the 150 mg/L treatment line. All cases above this line had documented N-acetylcysteine (NAC) administration. The association between self-reported dose and serum concentration was weak and non-significant in unadjusted analysis. **Conclusion:** In summary, our findings showed that a clinically actionable laboratory test loses much of its usefulness when emergency-care workflows fail to preserve the temporal information necessary for interpretation. Standardized recording of exposure and sampling times may improve risk stratification and support safer antidotal management of acute acetaminophen poisoning.

Clinical trial number: Not applicable.

Keywords: Acetaminophen, Poisoning, Emergency medicine, Serum concentration, N-acetylcysteine, Toxicology.

Background

Acetaminophen, also known as paracetamol, is one of the most widely used analgesic and antipyretic medications worldwide and is generally safe at therapeutic doses [1-3]. It remains a first-line option for the management of fever and mild to moderate pain across different age groups and clinical settings, with its broad availability as both a single-agent formulation and a component of combination products, including over-the-counter (OTC) medicines, facilitating widespread access [1,2,4–6]. Although generally safe at therapeutic doses, its widespread availability may increase the risk of accidental exposures, dosing errors, and intentional self-poisoning, particularly in contexts of self-medication and attempted suicide. Acetaminophen overdose may cause severe hepatotoxicity and acute liver failure due to NAPQI accumulation following glutathione depletion. N-acetylcysteine (NAC) is the specific antidote, with early administration improving treatment efficacy [2,5,7–11,13,14].

The early clinical presentation of acetaminophen poisoning may be absent or nonspecific, making symptoms and self-reported ingested dose insufficient for reliable risk stratification [2,15,16]. Serum acetaminophen concentration therefore plays a central role in the assessment of acute poisoning. In addition to supporting therapeutic decisions, serum acetaminophen quantification may help prevent unnecessary hospital admissions and optimize the use of healthcare resources by identifying low-risk patients who do not require intervention. For single acute ingestions with a known time of exposure, concentrations obtained between 4 and 24 h after ingestion can be interpreted using the Rumack–Matthew nomogram to guide NAC treatment [15-19]. Samples obtained before 4 h may precede complete absorption, whereas results obtained

outside the validated time window or without reliable timing information have limited nomogram-based interpretability [15,18,20,21].

Poison Information Centers provide an important setting in which these real-world challenges can be evaluated because they integrate toxicological consultation, clinical information, laboratory support, and toxicovigilance activities [7,22–24]. However, the extent to which laboratory results obtained in routine clinical practice can be effectively interpreted may depend on the completeness of the information accompanying the biological specimen.

Therefore, this study aimed to characterize acute acetaminophen poisoning cases referred for serum acetaminophen quantification through the Toxicological Information Center of Rio Grande do Sul (CIT-RS), Brazil, and to evaluate the clinical interpretability of measured concentrations, with particular emphasis on the availability of blood sampling-time information and documented ingestion-to-sampling interval within the 4-24 h nomogram window for Rumack–Matthew nomogram assessment, and recorded NAC administration.

Methods

Study design and data source

This retrospective descriptive study analyzed acetaminophen poisoning cases managed by the Toxicological Information Center of Rio Grande do Sul (CIT-RS), southern Brazil, from January 1, 2023, through December 31, 2025, for which blood samples were submitted to the CIT-RS laboratory for serum acetaminophen quantification. The CIT-RS operates continuously through a telephone consultation service and records clinical and toxicological information in the institutional electronic database CITonline.

All cases meeting the criterion of a blood sample submitted for serum quantification during the study period were included, with no additional exclusion criteria. The final dataset comprised 295 cases; because this was a census of acetaminophen poisoning cases referred to the Toxicological Information Center of Rio Grande do Sul (CIT-RS), Brazil, for serum acetaminophen quantification between, no a priori sample size calculation was performed. Extracted variables included year, sex, age, weight, circumstance of poisoning, self-reported ingested dose, toxic-dose classification, ingestion-to-sampling interval, serum acetaminophen concentration, co-ingested substances, clinical manifestations, hospitalization, NAC administration, aminotransferase results, and prognosis. Toxic dose was defined as at least 150 mg/kg in children or at least 7.5 g in adults for a single acute ingestion [3]. Records without sufficient information on dose, weight, or exposure pattern were classified as not reported. Prognosis followed the documentary categories used by the study center, and missing or unknown information was retained as such.

Ethics and consent

The data used in this study were available in the CIT-RS database; thus, ethics approval and consent to participate was waived.

Serum acetaminophen quantification

Serum acetaminophen was quantified using a previously developed and validated spectrophotometric method with detection at 430 nm and a lower limit of quantification of 20 mg/L [10]. Results below 20 mg/L were treated as nonquantifiable in descriptive analyses.

Rumack–Matthew nomogram assessment

For descriptive nomogram assessment, quantifiable serum acetaminophen concentrations with a documented ingestion-to-sampling interval were plotted relative to the Rumack–Matthew nomogram. Samples collected 4–24 h after reported ingestion were considered within the conventional nomogram time window; samples collected before 4 h were displayed for visualization only, and samples collected after 24 h were not interpreted with the nomogram [15,17,18,25]. The treatment line beginning at 150 mg/L at 4 h and the original 200 mg/L line were used as reference lines [15,17,25]. Clinical applicability of the nomogram additionally depends on a single acute ingestion with a known ingestion time [18].

Statistical analysis

Continuous variables were summarized as median and range or interquartile range, according to distribution and reporting purpose. Categorical variables were presented as absolute and relative frequencies. Percentages used the full analytical denominator ($N = 295$) unless a different valid denominator was specified. The association between self-reported ingested dose and serum acetaminophen concentration was explored in complete cases using Spearman correlation and multiple linear regression adjusted for the ingestion-to-sampling interval. Self-reported dose was log10-transformed. Missing data were handled by available-case or complete-case analysis, as appropriate, with denominators reported. No observations were excluded because of outlier status. Statistical significance was defined as $P < 0.05$. Analyses were performed using PSPP 2.0 and GraphPad Prism 10.0.

Large Language Models

During manuscript preparation, ChatGPT (OpenAI) and Microsoft Copilot (Microsoft) were used for language editing, structural refinement, and assistance with figure design. The authors reviewed and approved all AI-assisted content and remain fully responsible for the accuracy, interpretation, and integrity of the manuscript.

Results

Study population and epidemiological profile

From 2023 to 2025, 119,531 cases were recorded by the CIT-RS, including 4,331 acute acetaminophen poisonings (3.6%). Of these, serum acetaminophen quantification was performed in 295 cases, corresponding to 6.8% of acute acetaminophen poisoning records; all these cases were evaluated in this study.

Table 1 presents the clinical characteristics of the studied population. Among the 295 cases, 187 (63.4%) were female and 108 (36.6%) were male. Median age was 22.0 years (2 months-67 years), and median weight was 61.6 kg (3.0-126.0 kg; n = 280). Suicide attempts accounted for 231 cases (78.3%), followed by individual accidental exposures in 35 (11.9%); all accidental cases involved children aged 2 months to 6 years. A toxic dose was documented in 160 cases (54.2%), while 120 (40.7%) lacked sufficient information for classification. Median self-reported ingested dose was 10,000 mg (500-255,000 mg; n = 175). Aminotransferase results were available for 53 cases (18.0%), of which 12 (22.6%) were elevated. Hospitalization was documented in 207 cases (70.2%), and NAC administration in 191 (64.7%). Outcomes were classified as cure in 27.8% and supposed cure in 47.8%, although incomplete follow-up limited interpretation.

Table 1. Clinical characteristics of the studied cases

Characteristics	**Cases**
Age (*years*) (n= 295), median (range)	22.0 (2 months - 67.0)
Sex (n= 295)	*n* (%)
Female	187 (63.4)
Male	108 (36.6)
Weight (*kg*) (n= 280), median (range)	61.6 (3.0 - 126.0)
Circumstance of poisoning (n= 295)	*n* (%)
Suicide attempt	231 (78.3)
Individual accident	35 (11.9)
Management error	11 (3.7)
Misuse	8 (2.7)
Abuse/violence	2 (0.7)
Not reported	8 (2.7)
Toxic dose reached (n= 295)	*n* (%)
Yes	160 (54.2)
No	15 (5.1)
Not reported	120 (40.7)
Self-reported acetaminophen dose (mg) (n=175), median (range)	10,000 (500-255,000)
Hepatic transaminases determination (n= 295)	*n* (%)
Normal	41 (13.9)
Elevated	12 (4.1)

Not reported	242 (82.0)
Hospitalization (n= 295)	*n* (%)
Yes	207 (70.2)
No	37 (12.5)
Not reported	51 (17.3)
NAC administration (n= 295)	*n* (%)
Yes	191 (64.7)
Not reported	104 (35.3)
Prognosis (n= 295)	*n* (%)
Cure	82 (27.8)
Supposed cure	141 (47.8)
Patient escaped	7 (2.4)
Not reported	65 (22.0)

The largest age group was 20-29 years (35.9%), followed by 15-19 years (16.6%). Among suicide attempts (n = 231), the corresponding proportions were 43.7% and 21.2%; participants aged 15-29 years represented 64.9% of suicide-attempt records (Table 2).

Table 2. Age-group distribution of suicide attempts (n=231)

Age group (years)	n	%
10–14	25	10.8
15–19	49	21.2
20–29	101	43.7
30–39	33	14.3
40–49	15	6.5
50–59	5	2.2
60–69	3	1.3

Clinical manifestations and co-ingested substances

No clinical manifestation was documented for 126 cases (42.7%), whereas 169 (57.3%) had at least one manifestation. Neurological or central nervous system manifestations were most frequent (34.2%), followed by gastrointestinal manifestations (22.7%). Psychiatric or neuropsychiatric manifestations occurred in 5.1%; cardiovascular, hepatic, general or constitutional, and renal manifestations were less frequent (Figure 1).

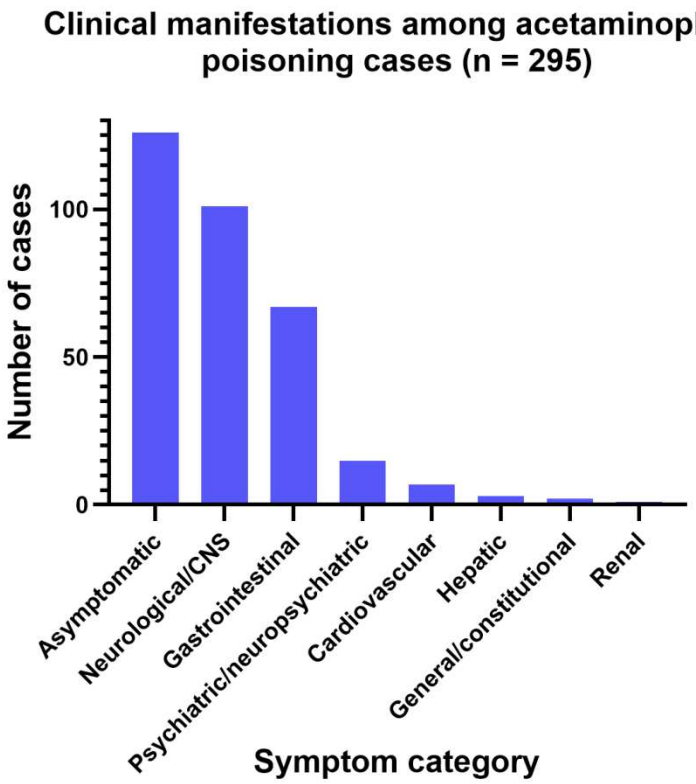

Figure 1. Clinical effects reported in acetaminophen poisoning cases (n=295). Categories are not mutually exclusive

Co-ingestion of at least one additional substance class was documented in 172 cases (58.3%). Among these cases, analgesics or antipyretics were most frequent (32.0%), followed by antidepressants (23.2%), nonsteroidal anti-inflammatory drugs and benzodiazepines (22.1% each), and muscle relaxants (13.4%). Cocaine, antipsychotics, antihistamines or alcohol, opioids, and antiemetics were less frequent (Figure 2).

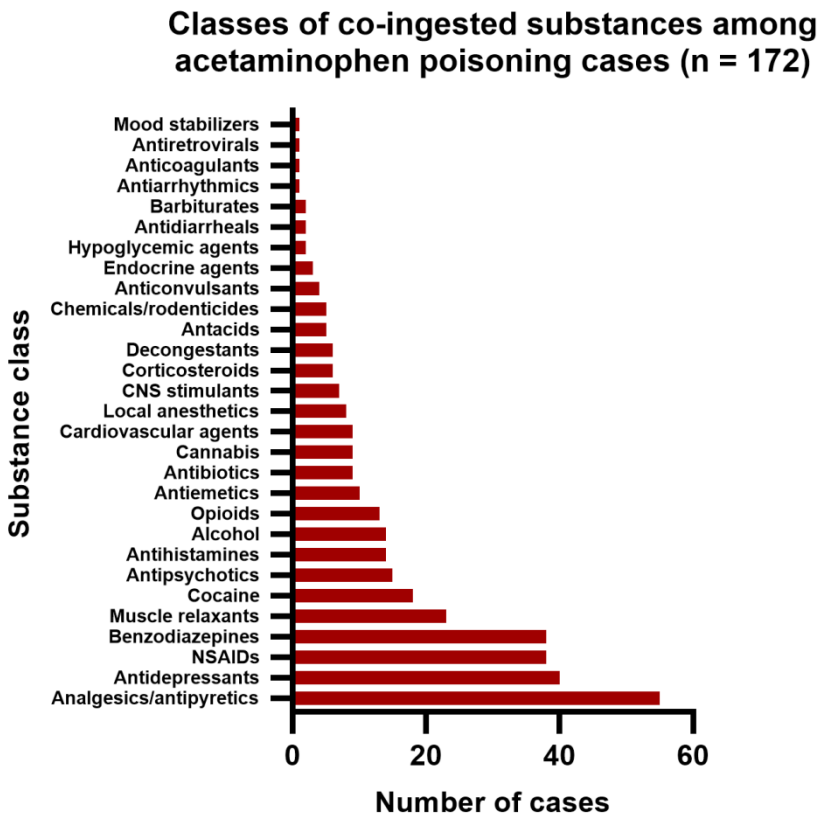

Figure 2. Classes of co-ingested substances in acetaminophen poisoning cases*
**Substance classes are not mutually exclusive because more than one additional agent could be recorded for the same poisoning event*

Serum acetaminophen concentration and sampling interval

As shown in Figure 3, among the 295 cases undergoing serum acetaminophen quantification, 133 samples have quantifiable serum acetaminophen results (≥ LLOQ of 20 mg/L), with a median concentration of 53.75 mg/L (21.0-339.0 mg/L). The ingestion-to-sampling interval was available for 138 cases (46.8%), with the blood collection performed in the nomogram time window (from 4 to 24 h) in 114 cases (38.6%), while 18 cases (6.1% of the full cohort) were collected before 4 h and six cases (2.0%) after 24 h (Table 3).

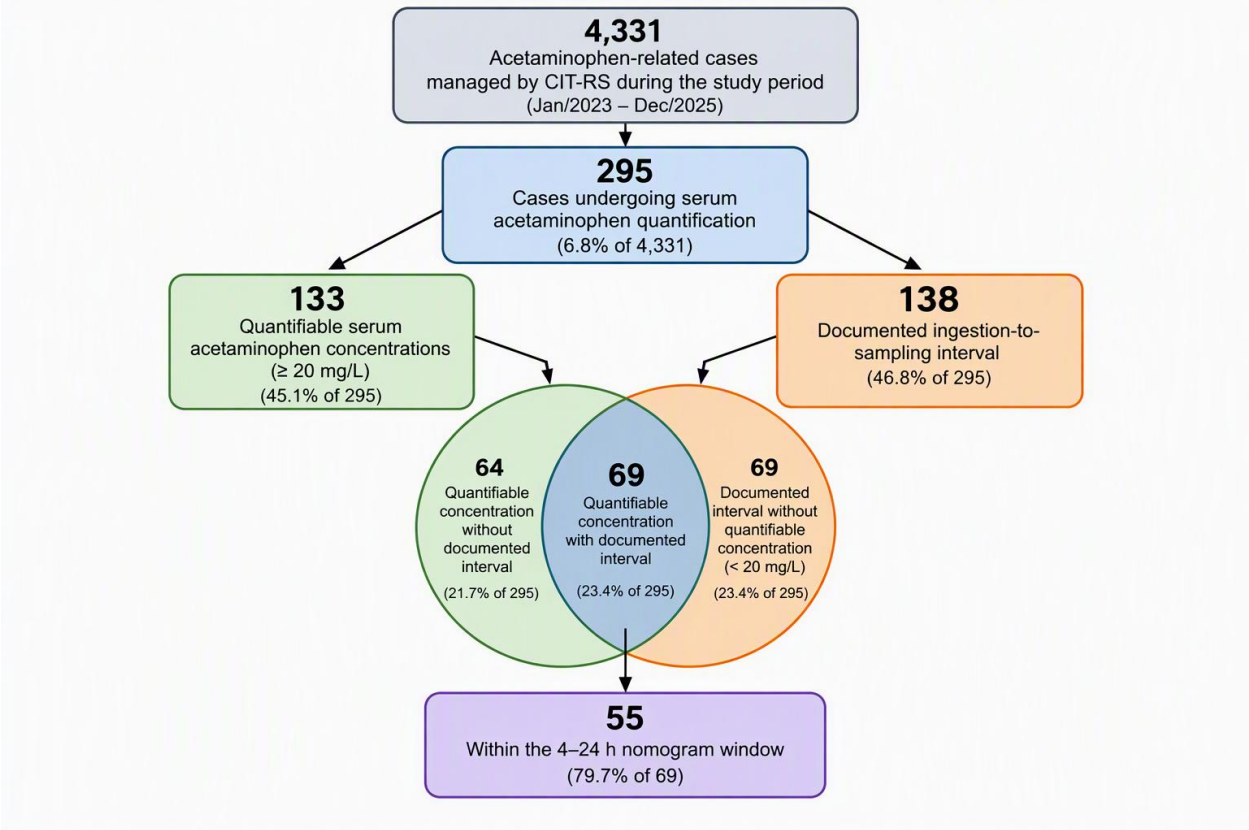

Figure 3. Availability of serum acetaminophen concentrations and temporal information required for clinical interpretation. Among 4,331 acetaminophen-related cases managed by CIT-RS during the study period, 295 underwent serum acetaminophen quantification. Quantifiable concentrations (≥20 mg/L) were obtained in 133 cases, while the ingestion-to-sampling interval was documented in 138. Sixty-nine cases had both a quantifiable concentration and a documented interval, of which 55 were sampled within the 4–24-h window used for Rumack–Matthew nomogram assessment. Abbreviations: CIT-RS, Toxicological Information Center of Rio Grande do Sul; LLOQ, lowe limit of quantification

Table 3. Serum acetaminophen concentration (mg/L) and blood sampling time of the studied cases (n= 295)

Serum acetaminophen concentration* (mg/L)	
Median (min.-max.)	53.75 (21.0-339.0)
	N (%)
< 20 mg/L (<LLOQ)	162 (54.9)
20–50 mg/L	63 (21.3)
51–100 mg/L	43 (14.6)
> 100 mg/L	27 (9.2)
Blood sampling time (h)	
	N (%)
Before 4 h post-ingestion	18 (6.1)
Between 4 h and 24 h post-ingestion	114 (38.6)
More than 24 h post-ingestion	6 (2.0)
Not reported	157 (53.2)

*Median concentration was calculated only for quantifiable results (n=133). Categorical distributions were calculated using the full dataset (n=295). LLOQ, lower limit of quantification.

Among quantifiable cases collected 4–24 h after reported ingestion with an available self-reported dose, the unadjusted correlation between dose and serum concentration was weak and not statistically significant (Spearman rho = 0.09; n = 49; P = 0.540). The multiple linear regression model including sampling interval was statistically significant (R^2 = 0.14; $P < 0.05$). Log10-transformed reported dose was positively associated with serum concentration (B = 46.43; $P <$

0.05), whereas the sampling interval showed a negative but not statistically significant association (B = -3.69; $P = 0.122$).

Rumack–Matthew nomogram

Sixty-nine cases had both a quantifiable acetaminophen concentration and a documented ingestion-to-sampling interval. Of these, 55 were sampled within the 4–24 h nomogram time window. Twenty-three of the 55 (41.8%) were above the 150 mg/L treatment line, including 13 (23.6%) above the original 200 mg/L line; all 23 had documented NAC administration. Thirty-two cases (58.2%) were below the treatment line. Ten quantifiable samples obtained before 4 h were plotted in Rumack-Matthew nomogram for visualization only, and four collected after 24 h were excluded from nomogram interpretation (Figure 4).

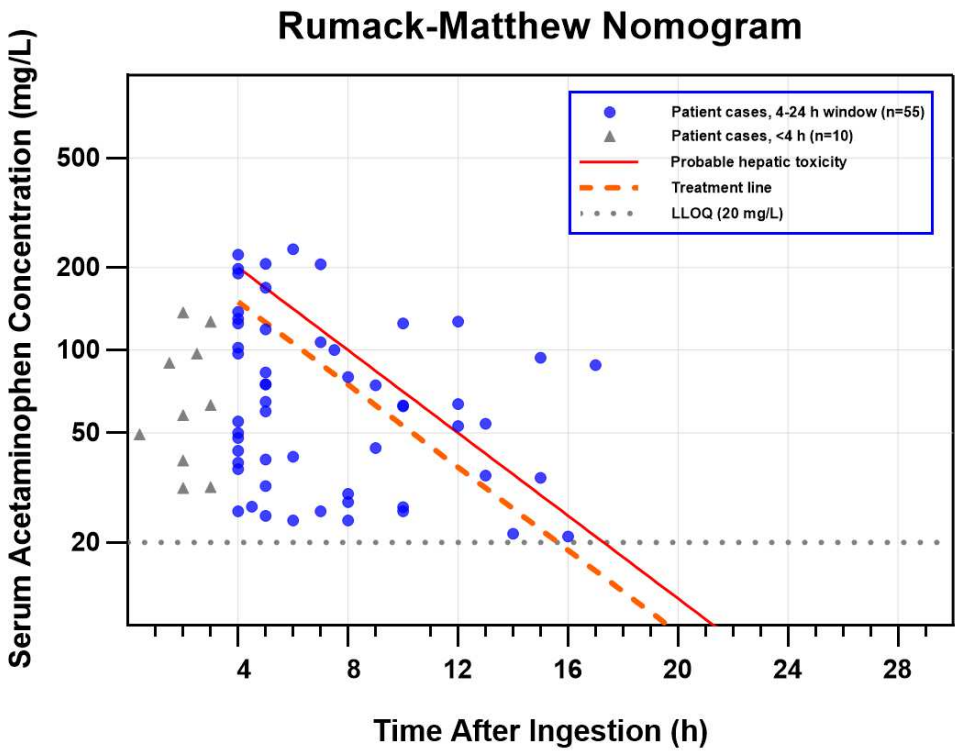

Figure 4. Acetaminophen concentrations plotted on the Rumack–Matthew nomogram (n=65)

Discussion

The main finding of this study was that incomplete temporal information substantially limited the clinical interpretation of serum acetaminophen concentrations in a real-world poison-center cohort. Blood sampling time was unavailable in 53.2% of cases, and only 55 cases had quantifiable concentrations, documented timing within the 4–24-h window, and sufficient information for systematic nomogram-based assessment. Among these cases, 41.8% were above the 150 mg/L treatment line, and all had documented NAC administration. These findings highlight that the clinical usefulness of serum acetaminophen testing depends not only on analytical performance but also on the availability of the temporal information required for interpretation.

The demographic profile was characterized by a predominance of females, young individuals, and intentional self-poisoning, consistent with previous reports of acetaminophen poisoning [4,6,22–24]. Suicide attempts accounted for 78.3% of cases, with adolescents and young adults representing an important subgroup. These findings reinforce the relevance of integrating toxicological management with appropriate psychosocial assessment and prevention strategies [1,2,26].

Co-ingestion was documented in 58.3% of cases and included analgesics, antidepressants, benzodiazepines, and other centrally acting substances. Co-ingested agents may contribute to clinical manifestations and, in some circumstances, alter acetaminophen absorption or the clinical course of poisoning [18,20,21]. The relatively frequent presence of analgesics, antidepressants, benzodiazepines, and other centrally acting substances in this cohort may also help explain why neurological manifestations were more frequently documented than would be expected from isolated acetaminophen poisoning. These findings support the need to interpret acetaminophen

concentrations within the broader toxicological and clinical context rather than as isolated laboratory values.

Serum acetaminophen quantification was performed in only 6.8% of the 4,331 acetaminophen-related cases managed by CIT-RS during the study period. Because our cohort included only cases referred for laboratory quantification, these data cannot establish how many of the remaining cases required serum testing. Nevertheless, this finding identifies an opportunity to further evaluate testing practices and clinical protocols. Serum acetaminophen measurements may provide objective information when exposure history is uncertain or clinical findings do not adequately reflect poisoning severity [15,19,27]. In emergency settings, appropriate access to and use of laboratory testing may therefore complement rather than replace clinical assessment.

More than half of serum results were below the lower limit of quantification. Such results should be interpreted in relation to sampling time because a low or nonquantifiable concentration obtained before 4 h may not reliably exclude subsequent clinically relevant concentrations [20,21]. More broadly, the absence of sampling-time information in 53.2% of records prevented reliable positioning of many results within the Rumack–Matthew nomogram. Thus, incomplete temporal documentation represents more than a missing data problem: it directly limits the conversion of an analytical measurement into a clinically interpretable risk estimate.

This finding has practical implications for emergency care. Recording the reported ingestion time and actual blood collection time as structured fields in clinical and poison-center records could facilitate calculation of the ingestion-to-sampling interval, identification of samples within the validated nomogram window, and communication between emergency clinicians, laboratories, and Poison Information Centers. The nomogram should, however, remain restricted to its validated context, particularly single acute ingestions with a known ingestion time [15,17,18,25].

Among patients with sufficient concentration and temporal information for descriptive nomogram assessment, 41.8% had concentrations above the 150 mg/L treatment line, and all had documented NAC administration. The study design does not allow assessment of treatment timing or adherence to a specific NAC protocol; nevertheless, this finding illustrates the clinical relevance of combining concentration measurements with reliable temporal information.

The weak, non-significant unadjusted correlation between self-reported dose and serum concentration also warrants consideration. Although reported dose became significantly associated with concentration after adjustment for sampling interval, the regression involved a substantially smaller complete-case subset and should be considered exploratory. Uncertainty in formulation, number of tablets, timing, recall, and reporting may affect dose estimates. Accordingly, reported dose remains clinically useful but should not substitute for objective concentration measurement when laboratory testing is indicated.

This study has several limitations. Its retrospective design made the analyses dependent on the completeness and accuracy of existing poison-center records, and inclusion was restricted to cases referred for serum quantification. Missing information affected several clinically relevant variables, particularly sampling time, aminotransferase measurements, NAC administration, and outcomes. The limited availability of aminotransferase results prevented a robust assessment of biochemical liver injury, while incomplete follow-up restricted evaluation of clinical outcomes. Furthermore, nomogram and dose–concentration analyses relied on smaller complete-case subsets, limiting statistical power and generalizability. In addition, the recorded ingestion time was based on information available in poison center records and may itself have been subject to uncertainty or recall error.

Despite these limitations, this study identifies a practical and potentially modifiable barrier to the clinical interpretation of acetaminophen concentrations. Standardized documentation of exposure and specimen-collection times, including structured electronic fields or laboratory requisition requirements, may improve the integration of laboratory testing with toxicological decision-making in emergency care.

Conclusion

In this Brazilian Poison Information Center cohort, incomplete documentation of ingestion and blood-sampling times substantially limited the clinical interpretability of serum acetaminophen concentrations and the systematic application of the Rumack–Matthew nomogram. More than half of cases lacked documented sampling-time information, illustrating that the clinical value of a toxicological measurement depends not only on analytical availability but also on the contextual information required for interpretation. Standardized recording of ingestion and specimen-collection times and better integration between emergency services, laboratories, and Poison Information Centers may improve risk assessment and support safer management of acute acetaminophen poisoning.

Declarations

Ethics approval and consent to participate

The data used in this study were available in the CIT-RS database; thus, ethics approval and consent to participate was waived.

Consent for publication

Not applicable.

Availability of data and material

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request, subject to applicable institutional restrictions.

Competing interests

The authors declare that they have no competing interests.

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No funding was obtained for this work.

Authors' contributions

IAMS contributed to study conceptualization, data collection, data curation, and manuscript drafting. BTS and MESD contributed to data collection and clinical data interpretation. VCS contributed to laboratory methodology and analytical interpretation. SNN contributed to study design, supervision, data interpretation, and critical revision of the manuscript. All authors read and approved the final manuscript.

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References

1. Ayoub SS. Paracetamol (acetaminophen): a familiar drug with an unexplained mechanism of action. Temperature (Austin). 2021;8(4):351-371. doi:10.1080/23328940.2021.1886392
2. Chidiac AS, Buckley NA, Noghrehchi F, et al. Paracetamol (acetaminophen) overdose and hepatotoxicity: mechanism, treatment, prevention measures, and estimates of burden of disease. Expert Opin Drug Metab Toxicol. 2023;19(5):297-317. doi:10.1080/17425255.2023.2223959
3. Bizovi KE, Smilkstein MJ. Acetaminophen. In: Goldfrank LR, Flomenbaum NE, Lewin NA, et al., editors. Goldfrank's Toxicologic Emergencies. 7th ed. New York: McGraw-Hill; 2002. p. 480-501.
4. Okuyama JHH, Galvao TF, Silva MT. Estimates of paracetamol poisoning in Brazil: analysis of official records from 1990s to 2020. Front Pharmacol. 2022;13:829547. doi:10.3389/fphar.2022.829547
5. Jaeschke H, Ramachandran A. Acetaminophen hepatotoxicity: paradigm for understanding mechanisms of drug-induced liver injury. Annu Rev Pathol. 2024;19:453-478. doi:10.1146/annurev-pathmechdis-051122-094016
6. Sanhueza-Aroca T, Verdugo-Silva S, Olate-Fica E, et al. Acetaminophen poisonings in Chilean healthcare settings: a 20-year story that does not end. Nepal J Epidemiol. 2021;11(4):1086-1094. doi:10.3126/nje.v11i4.38919
7. Iturra P, Silva L, Bettini M, et al. Aumento de intoxicaciones intencionales por paracetamol en Chile (2019-2023): estudio del Centro de Informacion Toxicologica UC. Rev Med Chil. 2025;153(2):85-95. doi:10.4067/s0034-98872025000200085

8. Melo LMA, Souza KAO, Lopes JEB, et al. Electrochemical methods for the determination of acetaminophen in biological matrices: a critical review in the clinical field. Anal Chim Acta. 2025;1333:343243. doi:10.1016/j.aca.2024.343243

9. Alrashed M, Alyousef A, Badreldin HA, et al. Comparison of three-bag method acetylcysteine versus two-bag method acetylcysteine for the treatment of acetaminophen toxicity: an updated systematic review and meta-analysis. Diseases. 2024;12(12):332. doi:10.3390/diseases12120332

10. Sebben VC, Lugoch RDW, Schlinker CS, et al. Validação de metodologia analitica e estudo de estabilidade para quantificacao serica de paracetamol. J Bras Patol Med Lab. 2010;46(2):143-148. doi:10.1590/S1676-24442010000200012

11. Aminoshariae A, Khan A. Acetaminophen: old drug, new issues. J Endod. 2015;41(5):588-593. doi:10.1016/j.joen.2015.01.024

12. Alhammad AM, Alajmi G, Alkhodair A, et al. Patterns of acetaminophen toxicity among patients with low-risk serum concentrations. J Int Med Res. 2024;52(7):03000605241260362. doi:10.1177/03000605241260362

13. Licata A, Minissale MG, Stankeviciute S, et al. N-acetylcysteine for preventing acetaminophen-induced liver injury: a comprehensive review. Front Pharmacol. 2022;13:828565. doi:10.3389/fphar.2022.828565

14. Codinach-Martin M, Ortega-Perez J, Gispert-Ametller MA, et al. N-acetylcysteine as an antidote for paracetamol poisoning: a multicenter study. Emergencias. 2022;34(3):190-195. doi:10.55633/s3me/E067.2022

15. Prescott LF. Paracetamol (acetaminophen) poisoning: the early years. Br J Clin Pharmacol. 2024;90(1):127-134. doi:10.1111/bcp.15903

16. Chomchai S, Mekavuthikul P, Phuditshinnapatra J, et al. Sensitivity of dose-estimations for acute acetaminophen overdose in predicting hepatotoxicity risk using the Rumack–Matthew nomogram. Pharmacol Res Perspect. 2022;10(1):e00920. doi:10.1002/prp2.920
17. Wong A, Graudins A. Risk prediction of hepatotoxicity in paracetamol poisoning. Clin Toxicol. 2017;55(8):879-892. doi:10.1080/15563650.2017.1317349
18. Dart RC, Mullins ME, Matoushek T, et al. Management of acetaminophen poisoning in the US and Canada: a consensus statement. JAMA Netw Open. 2023;6(8):e2327739. doi:10.1001/jamanetworkopen.2023.27739
19. Shihana F, Dissanayake D, Dargan P, et al. A modified low-cost colorimetric method for paracetamol (acetaminophen) measurement in plasma. Clin Toxicol. 2010;48(1):42-46. doi:10.3109/15563650903443137
20. Kirschner RI, Rozier CM, Smith LM, et al. Nomogram line crossing after acetaminophen combination product overdose. Clin Toxicol. 2016;54(1):40-46. doi:10.3109/15563650.2015.1110591
21. Yarema MC, Green JP, Sivilotti MLA, et al. Can a serum acetaminophen concentration obtained less than 4 hours post-ingestion determine which patients do not require treatment with acetylcysteine? Clin Toxicol. 2017;55(2):102-108. doi:10.1080/15563650.2016.1247959
22. Cairns R, Brown JA, Wylie CE, et al. Paracetamol poisoning-related hospital admissions and deaths in Australia, 2004-2017. Med J Aust. 2019;211(5):218-223. doi:10.5694/mja2.50296
23. Kumpula EK, Paterson DA, Pomerleau AC. A retrospective analysis of therapeutic drug exposures in New Zealand National Poisons Centre data 2018-2020. Aust N Z J Public Health. 2023;47(2):100027. doi:10.1016/j.anzjph.2023.100027

24. Casey D, Geulayov G, Bale E, et al. Paracetamol self-poisoning: epidemiological study of trends and patient characteristics from the multicentre study of self-harm in England. J Affect Disord. 2020;276:699-706. doi:10.1016/j.jad.2020.07.091

25. Rumack BH, Matthew H. Acetaminophen poisoning and toxicity. Pediatrics. 1975;55(6):871-876. doi:10.1542/peds.55.6.871

26. Brand F, Bale E, Tsiachristas A, et al. Self-poisoning with paracetamol in England: short report of characteristics of individuals and their overdoses according to source of tablets. BJPsych Open. 2024;10(5):e155. doi:10.1192/bjo.2024.740

27. Duffull SB, Isbister GK. Predicting the requirement for N-acetylcysteine in paracetamol poisoning from reported dose. Clin Toxicol. 2013;51(8):772-776. doi:10.3109/15563650.2013.830733