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ORIGINAL ARTICLE

Knowledge and Confidence of Emergency Clinicians in Managing Toxicological Presentations

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Abstract

Background: Acute poisonings are common presentations to emergency departments (EDs) worldwide and require rapid assessment. Consultant emergency physicians (EPs) faced with various toxicological presentations must initiate rapid investigations and empirical management. This study aimed to determine emergency department doctors' level of knowledge and confidence in toxicological presentations, and factors that predicted these outcomes.
Methods: Target participants included members of the Australasian College for Emergency Medicine (ACEM) and readers of the emergency medicine website, "Life in the Fast Lane". The survey was distributed electronically via the ACEM bulletin and posted on Life in the Fast Lane. A survey was designed based on toxicology multiple choice questions (MCQs). The questionnaire comprised 59 items: 10 demographic items; 20 items about confidence; 28 MCQs assessing knowledge of common and serious toxicological presentations.
Results: There were 467 consenting respondents from 31 countries, with most residing in Australia (306/467, 66%). Respondents comprised similar proportions of consultant emergency physicians (196/467, 42.0%), and trainees (197/467, 42.2%). Almost two-thirds (292/467; 62.1%) had received formal training in toxicological emergencies, while a third (166/467, 35.5%) had participated in a relevant conference or workshop. A total of 284/339 (83.8%) participants completing all items achieved a knowledge test score >50%. More than 65% incorrectly answered questions on pharmacology of serotonin syndrome and lithium toxicity, and more than half incorrectly answered questions on use of 12 lead ECG in toxicology, calcium channel antagonist or tricyclic antidepressant toxicities. Predictors of overall knowledge for toxicology were receipt of formal toxicology education, and clinicians' experience and seniority.
Conclusion: The knowledge and confidence of doctors working in emergency departments is varied, yet correlated. Emergency medicine training programs should consider the benefit of reviewing current toxicological education, including the provision of further educational support to regional and rural hospitals.

Keywords: Clinical Assessment; Education; Emergency Care System; Emergency Medicine; Toxicology

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INTRODUCTION

Acute poisonings are common presentations to emergency departments (EDs) worldwide and require rapid assessment. In 2009-2010, poisonings accounted for over 35,000 hospital admissions in Australia and many more ED presentations (1). These numbers are increasing in Australia, and internationally (1-4). Accordingly, the need for specialist knowledge has culminated in the emergence of clinical toxicology as an important sub-specialty.

The most common poisonings are with pharmaceuticals, followed by corrosive and caustic agents, glues, adhesives, soaps, detergents, paints, and dyes. In Australia, unintentional pharmaceutical poisoning accounted for 6865 hospital admissions in 2009-2010, with children 0-4 years, and those aged 25-44 most affected (20% and 27%, respectively). Unintentional poisoning with other substances was responsible for 2523 hospital separations (1). Together, these poisonings resulted in 21164 inpatient days (1). Accidental poisoning accounted for 864 (0.6%) deaths in 2010, with more than twice as many males as females, and median age 41.8 years (5). Poisoning due to deliberate self-harm is also common. The abundance of possible causative agents has made toxicology essential to Australasian emergency physician training (5).

Toxicology is frequently regarded as a subspecialty of emergency medicine rather than a requisite skill for all (2). It is, however, unrealistic to have a specialized team of toxicologists based at all EDs covering the 24 hour/day service provision. The incorporation of knowledge and skills in managing common toxicological presentations among all ED doctors is arguably more practical.

Consultant emergency physicians (EPs) faced with various toxicological presentations must initiate rapid investigations and empirical management. This requires a broad knowledge base (6).

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A systematic, consistent education through which emergency clinicians can develop this knowledge, however, is lacking. To date, no study has examined currently practicing ED clinicians' knowledge or confidence in managing toxicological presentations and how these practices compare to accepted management. This study was performed to assess emergency and toxicology clinicians' current knowledge of common and serious toxicological presentations and principles of toxicology. The second objection of this study was to evaluate clinicians' confidence in managing toxicological emergencies.

METHODS

Study design and ethics

This survey used a convenience sample and was approved by the hospital ethics committee, and the Scientific Committee of the Australasian College for Emergency Medicine (ACEM).

Inclusion criteria

Target participants included (1) members (Fellows, Provisional or Advanced Trainees and career medical officers) of the ACEM working clinically in EDs in Australia or New Zealand. ACEM membership was approximately 3800; and (2) readers of the global emergency medicine website, Life in the Fast Lane (http://lifeinthefastlane.com/), a website with high hit count from emergency clinicians primarily based in Australia, New Zealand, USA and Europe.

Tool development and validation

A survey was designed based on toxicology multiple choice questions (MCQs) written by two EPs, a clinical toxicologist, and confirmed using emergency medicine textbooks (7,8). Face validity was ensured using iterative feedback from four EPs, one pharmacist and a researcher resulting in minor changes. Content validity was verified by six EPs and five trainees who rated relevance items through a pilot survey on a four-point scale (9).

The final questionnaire (Appendix A) comprised 59 items: 10 demographic items; 20 items about confidence; 28 MCQs assessing knowledge of common and serious toxicological presentations. Participants were offered answers to the knowledge questions at study conclusion. Likert scales were used for attitudinal questions, binary response formats for demographics, and multi-category format (demographics, knowledge questions, further training in toxicological emergencies). Some open-ended questions were also included.

Survey distribution

The electronic survey used Survey Monkey™ online software. A link to the survey was uploaded to http://lifeinthefastlane.com. Additionally, the study was advertised in a bulletin distributed by ACEM to members in March 2014. All participants received an invitation, and a participant information form. Surveys were delivered via hyperlink to the online questionnaire embedded in the bulletin and website post.

Primary outcome

The primary outcome was the proportion of respondents obtaining a pass mark on the knowledge test, defined a priori as >50% total score (>12/24) calculated by summing correct answers for participants answering all questions.

Sample size

Based on an ACEM membership of 3800 (1600 EPs, 2200 Trainees) a sample size of 380 was required to estimate the proportion of respondents passing the knowledge test within a 5% margin of error (assuming a 50% response distribution) at a 95% confidence level (10). This equates to a 50% pass rate for the knowledge portion of the survey. This figure was chosen as it provides the most conservative estimate maximizing the sample size required. Further power analyses indicated that a sample size of 346 would be sufficient to detect a difference in two proportions of 15 percentage points (50% vs 65%) with power at 80% and criterion for significance set at 0.05. For multiple regression analyses, the sample size was defined by the rule of thumb, that number of cases = 50 + (8 x number of predictors).

Data Analysis

Quantitative data were analyzed using SPSS 20.0 (Chicago, IL). For each item, summary statistics (%, 95% confidence interval (CI)) were calculated. Arithmetic mean was used to summarize total number of correct knowledge items. All data reported were adjusted for missing data on an item-by-item basis.

Total confidence was calculated by summing collapsed items for confidence. Similarly, a total score was calculated for each participant completing all items in the knowledge test, excluding Australian-specific toxinology questions. Items were identified as either correct/incorrect prior to summation. Internal consistency of items was verified requiring Cronbach's alpha >.80.

Multiple regression ('enter method') was used to identify (demographic) predictors of knowledge score and all predictors of total confidence. For total knowledge, predictors assessed were: Staff Type (career medical officer (CMO)/provisional trainee/advanced trainee/EP/clinical toxicologist/other); ED type (adult/other); whether formal education in toxicology had been received (yes/no); whether the respondent had participated in a conference workshop on toxicology (yes/no); hospital type (rural or regional/urban/tertiary referral); years' experience in emergency (0-5/6-10/11+) and staff type (CMO/provisional trainee/advanced trainee/EP/consultant toxicologist/other). For confidence, these same predictors were included in the model with the addition of total percentage knowledge score. Variance inflation factor (VIF) was used to assess multi-collinearity with VIF<5 set for retention of variables. Other assumptions (outliers, linearity, homoscedasticity and independence of residuals) were assessed by inspecting the residuals scatterplot and the normal probability plot of regression standardized residuals. Pearson's correlation was used to explore an association between knowledge score and total confidence score. Alpha was set at 0.05 and two tailed tests of significance were used.

RESULTS

A total of 598 respondents were recruited; 467 proceeded past consent, 278 completed all survey items and 189 completed some survey items; 467 completed some or all (n=434) demographic items; 421 completed some or all (n=339) of the knowledge section; 324 completed some or all (n=299) confidence items. Respondents completing all items did not differ significantly from non-completers in demographics

except Victorian-based (Australia) respondents were more likely to complete the survey compared with others.

Demographics

Respondents represented 31 countries; most from Australia (306/467, 65.5%), the United States of America (40/467, 8.6%), New Zealand (23/467, 4.9%), Canada (20/467, 4.3%) and the United Kingdom (21/467, 4.5%). Over two-thirds worked in EDs receiving both adults and children (adult: 147(31.5%); pediatric only: 6 (1.3%); mixed: 314 (67.2%)). Data for pediatric and mixed hospitals were collapsed for subsequent analyses. The majority of respondents worked in tertiary referral hospitals (tertiary referral: 199 (42.6%); metropolitan/urban: 148 (31.7%); regional: 88 (18.8%); rural/ remote: 32 (6.9%)). Data for regional and rural/remote hospitals were subsequently collapsed.

The majority of respondents were trainees (197/467, 42.2%) or EPs (196/467, 42.0%). There were small numbers of CMOs (34/467, 7.3%), and toxicologists (17/467, 3.6%). Five-percent of respondents indicated their staff type as 'other' (23/467, 4.9%). Respondents varied in years of ED experience, with fewer than 5 years being most common (0-5 years: 194 (41.5%); 6-10 years: 140 (30.0%); 11 or more years: 133 (28.5%)).

Overall, 292 (62.1%) respondents reported receiving formal training in toxicological emergencies, while 166/467 (35.5%) indicated participating in a conference or workshop specifically on toxicological emergencies, while others received no training outside that obtained on the job. Most indicated access to on-call toxicologists in ED (324/467, 69.4%), but one fifth reported no access to specialist toxicological services or advice (87/467, 18.6%). A small proportion were unaware of what local toxicological assistance was available (39/467, 8.4%), and 17 reported accessing staff from other hospitals.

Knowledge of toxicological emergencies

The mean (95% CI) total knowledge score out of a possible 24 was 16.7 ± 1.1 (range 3-24). 284 participants of 339 (83.8%) completing all items passed (≥50%) the knowledge test. Knowledge varied across topics (Table 1). Topics with the highest percentage of respondents answering correctly included tricyclic antidepressant toxicity (K19, K14; 85.3%-95%) and paracetamol toxicity (K24, K12; 90.6%-91.2%). Topics with the lowest percentage and subsequently scoring below 50% included pharmacology of lithium toxicity (K23; 33.7%), serotonin toxicity (K16; 28.4%), interpreting 12 lead ECGs in toxicological presentations (K3; 44.4%), and calcium channel antagonist toxicity (K9; 45.2%).

Table 1. Percentage (95% CI) of participants answering knowledge item correctly

Item	Percentage (95%CI); numerator/denominator
General toxicology (K1)	58.4 (53.7-63.0); 246/421
Decontamination (K2)	79.3 (75.2-82.9); 334/421
12 lead ECG in toxicology (K3)	44.2 (39.5-49.0); 186/421
Household products (K4)	63.4 (58.7-67.9); 267/421
Polysubstance abuse case (K5)	81.5 (77.5-84.9); 343/421
Oral activated charcoal (K6)	84.1 (80.3-87.3); 354/421
Quetiapine (Seroquel) overdose (K7)	78.0 (73.3-82.1); 266/341
Alcohol (methanol, ethylene glycol) ingestion (K8)	71.0 (65.9-75.5); 242/341
Calcium channel antagonist toxicity (K9)	45.2 (40.0-50.5); 154/341
Salicylate toxicity (K10)	66.8 (61.6-71.6); 227/340
Paracetamol toxicity case (K11)	60.4 (55.1-65.5); 206/341
Paracetamol toxicity case continued (K12)	90.6 (87.0-93.3); 308/340
Tricyclic antidepressant toxicity case (K13)	79.2 (74.5-83.2); 270/341
Tricyclic antidepressant toxicity case continued (K14)	95.0 (92.1-96.9); 324/341
Serotonin toxicity/syndrome (K15)	56.0 (50.7-61.2); 191/341
Serotonin toxicity/syndrome (K16)	28.4 (23.9-33.5); 97/341
Paracetamol toxicity case 2 (K17)	81.2 (76.7-85.0); 277/341
Tricyclic antidepressant toxicity case 2 (K18)	48.7 (43.4-54.0); 166/341
Tricyclic antidepressant toxicity case 2 continued (K19)	85.3 (81.2-88.7); 291/341
IV sodium bicarbonate therapy in antidepressant toxicity (K20)	79.5 (74.9-83.4); 271/341
Calcium channel antagonist toxicity case (K21)	83.3 (78.9-86.9); 284/341
Valproic acid toxicity case (K22)	66.6 (61.4-71.4); 227/341
Lithium toxicity case (K23)	33.7 (28.9-38.9); 115/341
Paracetamol toxicity case 3 (K24)	91.2 (87.7-93.8); 311/341

Table 2. Percentage of knowledge questions answered correctly according to staff type.

Item	Staff Type. Number/denominator, Percentage				
	CMO (n = 32)	EM Trainees (n = 184)	Consultant EM Physicians (n = 170)	Toxicologists (n = 17)	Other (n = 18)
General toxicology (K1)	8/32, 25.0	104/184, 56.5	115/170, 67.6*	16/17, 94.1*	3/18, 16.7‡
Decontamination (K2)	18/32, 56.3‡	148/184, 80.4	147/170, 86.5*	16/17, 94.1	5/18, 27.8‡
12 lead ECG in toxicology (K3)	6/32, 18.8‡	88/184, 47.8	77/170, 45.3	15/17, 88.2*	0/18, 0.0‡
Household products (K4)	12/32, 37.5‡	136/184, 57.6‡	128/170, 75.3*	17/17, 100.0*	4/18, 22.2‡
Polysubstance abuse case (K5)	22/32, 68.8	142/184, 77.2‡	153/170, 90.0*	15/17, 88.2	11/18, 61.1‡
Oral activated charcoal (K6)	22/32, 68.8‡	146/184, 79.3‡	162/170, 95.3*	16/17, 94.1	8/18, 44.4‡
Quetiapine (Seroquel) overdose (K7)	16/26, 61.5‡	113/147, 76.9	114/139, 82.0	17/17, 100.0*	6/12, 50.0‡
Alcohol (methanol, ethylene glycol) ingestion (K8)	14/26, 53.8‡	101/147, 68.7	108/139, 77.7*	15/17, 88.2	4/12, 33.3‡
Calcium channel antagonist toxicity (K9)	8/26, 30.8	65/147, 44.2	67/139, 48.2	13/17, 76.5*	1/12, 8.3‡
Salicylate toxicity (K10)	8/26, 30.8‡	87/147, 59.2‡	111/138, 80.4*	15/17, 88.2	6/12, 50.0
Paracetamol toxicity case (K11)	5/26, 19.2‡	85/147, 57.8	101/139, 72.7*	14/17, 82.4	1/12, 8.3‡
Paracetamol toxicity case continued (K12)) †	19/26, 73.1‡	134/147, 91.2	132/139, 95.0*	16/16, 100.0	7/12, 58.3‡
Tricyclic antidepressant toxicity case (K13)	12/26, 46.2‡	118/147, 80.3	118/139, 84.9*	16/17, 94.1	6/12, 50.0‡
Tricyclic antidepressant toxicity case continued (K14)) †	20/26, 76.9‡	141/147, 95.9	139/139, 97.8*	17/17, 100.0	10/12, 83.3
Serotonin toxicity/syndrome (K15)	9/26, 34.6	78/147, 53.1	87/139, 62.6*	16/17, 94.1*	1/12, 8.3
Serotonin toxicity/syndrome (K16)	4/26, 15.4‡	27/147, 18.4‡	50/139, 36.0*	15/17, 88.2*	1/12, 8.3‡
Paracetamol toxicity case 2 (K17) †	12/26, 46.2‡	115/147, 78.2	127/139, 91.4*	17/17, 100.0*	6/12, 50.0‡
Tricyclic antidepressant toxicity case 2 (K18)	5/26, 19.2‡	63/147, 42.9	83/139, 59.7*	15/17, 88.2*	0/12, 0.0‡
Tricyclic antidepressant toxicity case 2 continued (K19) †	17/26, 65.4‡	121/147, 82.3	128/139, 92.1*	17/17, 100.0	8/12, 66.7
IV sodium bicarbonate therapy in antidepressant toxicity (K20)	17/26, 65.4	111/147, 75.5	120/139, 86.3*	16/17, 94.1	7/12, 58.3
Calcium channel antagonist toxicity case (K21)	14/26, 53.8‡	121/147, 82.3	126/139, 90.6*	17/17, 100.0	6/12, 50.0‡
Valproic acid toxicity case (K22)	15/26, 57.7	92/147, 62.6	97/139, 69.8	17/17, 100.0*	6/12, 50.0
Lithium toxicity case (K23)	3/26, 11.5‡	39/147, 26.5‡	59/139, 42.4*	14/17, 82.4*	0/12, 0.0‡
Paracetamol toxicity case 3 (K24) †	18/26, 69.2‡	135/147, 91.8	130/139, 93.5	17/17, 100.0	11/12, 91.7

‡ Denotes significantly under-represented compared to other groups (according to adjusted standardised residuals)
* Denotes significantly over-represented compared to other groups (according to adjusted standardised residuals)
† Test of significance violated assumption of chi square resulting in invalid test.

Seniority in staff type was significantly associated with better performance in most knowledge questions (Table 2). Toxicologists and EPs typically scored significantly better than their colleagues, while CMOs and those in the "other" staff group frequently scored significantly lower.

Receipt of formal toxicology education was significantly associated with correct knowledge for 10 toxicology topics, particularly knowledge in managing tricyclic antidepressant toxicity, serotonin syndrome recognition and management of paracetamol toxicity (Table 3). Participation in toxicology conferences or workshops was significantly associated with correct answers on more than half of the knowledge items.

Knowledge varied significantly by hospital type for just over half of the topics. The most significant were: using oral activated charcoal (p=.001; rural or regional hospitals: 78/106, 73.6%, 95% CI 64.4-81.1; urban or metropolitan hospitals: 116/137, 84.7%, 95% CI 77.6-89.8; tertiary referral hospitals: 160/178, 89.9%, 95% CI 84.5-93.6); principles of decontamination (p=.003; rural or regional hospitals: 74/106, 69.8%, 95% CI 60.5-77.8; urban or metropolitan hospitals: 106/137, 77.4%, 95% CI 69.6-83.6; tertiary referral hospitals: 154/178, 86.5%, 95% CI 80.7-90.8) and managing salicylate toxicity (p=.003; rural or regional hospitals: 43/81, 53.1%, 95% CI 42.3-63.6; urban or metropolitan hospitals: 73/111, 65.8%, 95% CI 56.5-74.0; tertiary referral hospitals: 111/148, 75.0%, 95% CI 67.4-81.3). Clinicians working in an adult ED were significantly more knowledgeable in managing salicylate poisonings compared to clinicians working in pediatric or mixed EDs (84/110, 76.4%, 95% CI 66.9-82.8; 143/230, 62.2%, 95% CI 55.8-68.2, p=.010). Knowledge

Table 3. Percentage of knowledge questions answered correctly according to formal toxicology education and participation in toxicology workshops or conferences.

Item	Number/denominator, Percentage			
	Received formal toxicology education†		Participates in toxicology workshops or conferences†	
	Yes	No	Yes	No
General toxicology (K1)	162/262, 61.8	84/159, 52.8	112/147, 76.2	134/274, 48.9***
Decontamination (K2)	215/262, 82.1	119/159, 72.8	123/147, 83.7	211/274, 77. 0
12 lead ECG in toxicology (K3)	129/262, 49.2	57/159, 35.8**	78/147, 53.1	108/274, 39.4**
Household products (K4)	178/262, 67.9	89/159, 56.0*	110/147, 74.8	157/274, 57.3***
Polysubstance abuse case (K5)	217/262, 82.8	126/159, 79.2	126/147, 85. 7	217/274, 79.2
Oral activated charcoal (K6)	229/262, 87.4	125/159, 78.6*	138/147, 93.9	216/274, 78.8***
Quetiapine (Seroquel) overdose (K7)	174/220, 79.1	92/121, 76.0	103/124, 83.1	163/217, 75.1
Alcohol (methanol, ethylene glycol) ingestion (K8)	164/220, 74.5	78/121, 64.5	94/124, 75.8	148/217, 68.2
Calcium channel antagonist toxicity (K9)	109/220, 49.5*	45/121, 37.2	71/124, 57.3	83/217, 38.2***
Salicylate toxicity (K10)	154/220, 70.0	73/120, 60.8	91/124, 73.4	136/216, 63.0
Paracetamol toxicity case (K11)	84/220,61.8	70/121, 57.9	82/124, 66.1	124/217, 57.1
Paracetamol toxicity case continued (K12)	206/219, 94.1	102/121, 84.3**	120/123, 97.6	188/217, 86.6***
Tricyclic antidepressant toxicity case (K13)	187/220, 85.0	83/121, 68.6***	108/124, 87.1	162/217, 74.7**
Tricyclic antidepressant toxicity case continued (K14)	220/221, 96.4	112/121, 92.6	120/124, 96.8	204/217, 94.0
Serotonin toxicity/syndrome (K15)	136/220, 61.8	55/121, 45.5**	84/124, 67.7	107/217, 49.3***
Serotonin toxicity/syndrome (K16)	67/220, 30.5	30/121, 24.8	47/124, 37.9	50/217, 23.0**
Paracetamol toxicity case 2 (K17)	188/220, 85.5	89/121, 73.6**	105/124, 84.7	172/217, 79.3
Tricyclic antidepressant toxicity case 2 (K18)	114/220, 51.8	52/121, 43.0	72/124, 58.1	94/217, 43.3***
Tricyclic antidepressant toxicity case 2 continued (K19)	192/220, 87.3	99/121, 81.8	116/121, 93.5	175/217, 80.6***
IV sodium bicarbonate therapy in antidepressant toxicity (K20)	176/220, 80.0	95/121, 78.5	106/124, 85.5	165/217, 76.0
Calcium channel antagonist toxicity case (K21)	188/220, 85.5	96/121, 79.3	107/124, 86.3	177/217, 81.6
Valproic acid toxicity case (K22)	156/220, 70.9	71/121, 58.7*	97/124, 78.2	130/217, 59.9***
Lithium toxicity case (K23)	85/220, 38.6	30/121, 24.8*	62/124, 50.0	53/217, 24.4***
Paracetamol toxicity case 3 (K24)	199/220, 90.5	112/121, 92.6	116/124, 93.5	195/217, 89.9

†† Inferential analyses conducted using Fisher's Exact Test
* P < 0.05
** P < .01
*** P < 0.05

varied significantly by experience in emergency medicine for most toxicology topics, generally with respondents with 0-5 or 6-10 years of experience having higher levels of knowledge (Table 4).

Confidence in toxicological emergencies

Total confidence score was positively correlated with total knowledge score (r=0.484, p<.001). Confidence for tasks relating to management of toxicological emergencies ranged from 24% of participants (77/321) reporting confidence in managing chloroquine poisoning to 78.9% (255/323) for managing paracetamol poisoning (Figure 1). Receipt of formal toxicology education was significantly associated with confidence for more than half the toxicology topics, particularly in recognizing toxidromes and in interpretation of ECGs in toxicological presentations (Table 5). Participation in toxicology conferences or workshops was significantly associated with confidence for 13 of 17 toxicology topics (Table 5), and confidence was frequently significantly higher among EPs and Toxicologists and lower among trainees (Table 6).

Confidence varied significantly by hospital type for five toxicology topics, with more respondents from tertiary referral hospitals reporting confidence than those from urban and metropolitan hospitals, who in turn were more likely to report confidence than those from regional, rural and remote hospitals: recognizing toxidromes (p=.008; rural or regional: 35/77, 45.5%; urban or metropolitan: 61/104, 58.7%; tertiary referral: 96/14367.1%); interpretation of ECGs in toxicological presentations (p=.014; rural or regional: 45/77, 58.4%,; urban or metropolitan: 68/104, 65.4%; tertiary referral: 109/142, 76.8%); using medications to treat specific toxicities (p=.021, rural/regional:39/76, 51.3%; urban/metropolitan: 62/101, 61.4%; tertiary referral: 99/141, 70.2%); managing sympathomimetic toxicity (p=.020,

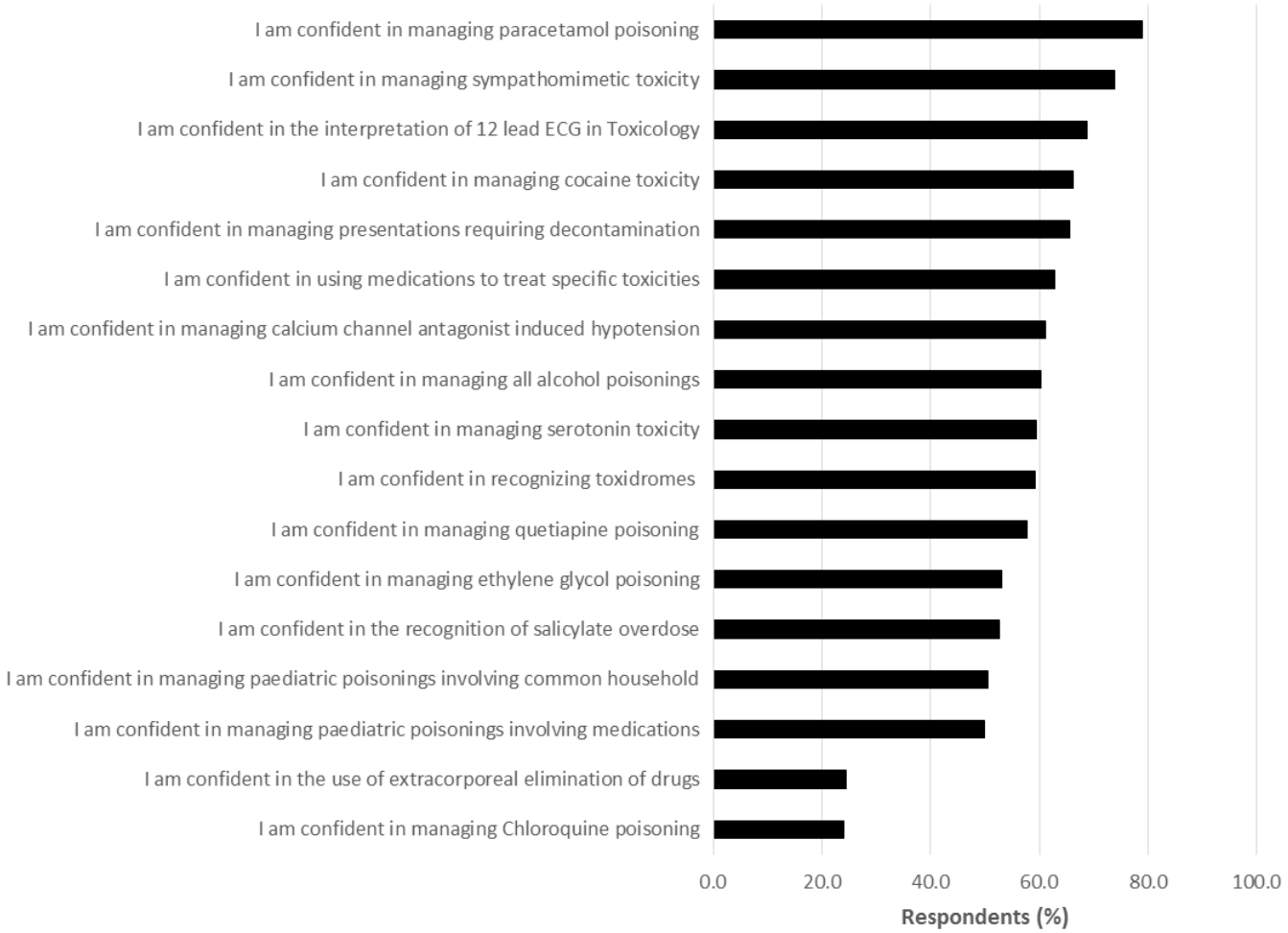

Figure 1. Percentage of respondents who agreed/strongly agreed to stat

rural/regional: 50/76, 65.8%;urban/metropolitan: 71/102, 69.6%; tertiary referral: 115/141, 81.6%; managing cocaine toxicity: p=.012, rural/regional: 41/77, 53.2%; urban/metropolitan: 56/103, 67.0%; tertiary referral: 79/140, 73.0%). Clinicians working in a pediatric only ED or mixed ED were significantly more confident in managing pediatric poisonings involving medications compared to clinicians working in adult EDs (p=.043, 118/218, 54.1% vs 43/104, 41.3%). Confidence varied significantly by experience for all topics except managing extracorporeal elimination and chloroquine poisoning. Those with increasing years of experience generally had higher confidence.

Predictors of knowledge and confidence

For total knowledge score, independent predictors included receipt of formal education in toxicology(β=1.99 (95%CI 0.73-3.24), p=.002), being a trainee (β=5.63 (2.58-8.68) p<.001), EP (β=6.26 (3.08-8.68) p<.001), or toxicologist (β=11.43 (7.08-15.79) p<.001); and years of experience: having either 6-10 (β=2.78 (1.16-4.26) p<.001) or 11 (β=2.78 (0.90-4.66), p=.004) or more years of experience in emergency was significantly associated with greater knowledge when compared to those with 0-5 years of experience.

Significant predictors for total confidence score were total score on the knowledge test (β=0.79 (95%CI 0.55-1.02) p<.001), having 6-10 years of experience (versus 0-5) (β= 2.39 (0.5-4.74) p=.046), receiving formal education (β=2.39 (4.77-4.31) p=.001), and being a toxicologist (β= 12.32 (5.26-19.37) p=.001).

DISCUSSION

Toxicological presentations to EDs are increasing in incidence (1-4). These presentations can be rapidly progressive and potentially fatal, thus toxicology is an essential part of the emergency clinician's knowledge. Poor knowledge can lead to poor patient outcomes as well as inappropriate and ineffective management (11,12).

Within emergency medicine, this was the first study to comprehensively examine the knowledge and confidence of clinicians for a range of toxicological presentations. Others have focused on specific topics (e.g., examination of knowledge for the use of single dose oral activated charcoal), knowledge of medical students, or practice issues, but are difficult to compare and contrast due to the scenario-based or location-specific nature of knowledge examination (13-16).

Table 4. Percent correct of knowledge questions according to years of experience in emergency medicine

	Years of experience in emergency medicine Number/denominator, Percentage			
Item	0-5	6-10	11+	P value†
General toxicology (K1)	71/167, 42.5	79/119, 66.4	75/107, 70.1	< 0.001
Decontamination (K2)	121/167, 72.5	100/119, 84.0	91/107, 85.0	0.014
12 lead ECG in toxicology (K3)	58/167, 34.7	64/119, 53.8	45/107, 42.1	0.006
Household products (K4)	78/167, 46.7	85/119, 71.4	82/107, 76.6	< 0.001
Polysubstance abuse case (K5)	125/167, 74.9	100/119, 84.0	95/107, 88.8	0.010
Oral activated charcoal (K6)	121/167, 72.5	109/119, 91.6	99/107, 92.5	< 0.001
Quetiapine (Seroquel) overdose (K7)	88/122, 72.1	77/100, 77.0	80/93, 86.0	0.051
Alcohol (methanol, ethylene glycol) ingestion (K8)	80/122, 65.6	78/100, 78.0	63/93, 67.7	0.110
Calcium channel antagonist toxicity (K9)	47/122, 38.5	52/100, 52.0	43/93, 46.2	0.129
Salicylate toxicity (K10)	73/122, 59.8	68/99, 68.7	69/93, 74.2	0.077
Paracetamol toxicity case 1 (K11)	63/122, 51.6	66/100, 66.0	58/93, 62.4	0.075
Paracetamol toxicity case continued (K12)	108/122, 88.5	92/100, 92.0	87/93, 93.5	0.409
Tricyclic antidepressant toxicity case (K13)	92/122, 75.4	89/100, 89.0	71/93, 76.3	0.024
Tricyclic antidepressant toxicity case continued (K14)	113/122, 92.6	99/100, 99.0	88/93, 94.6	0.081
Serotonin toxicity/syndrome (K15)	64/122, 52.5	53/100, 53.0	55/93, 59.1	0.576
Serotonin toxicity/syndrome (K16)	23/122, 18.9	25/100, 25.0	35/93, 37.6	0.008
Paracetamol toxicity case 2 (K17)	89/122, 73.0	88/100, 88.0	79/93, 84.9	0.009
Tricyclic antidepressant toxicity case 2 (K18)	45/122, 36.9	54/100, 54.0	53/93, 57.0	0.005
Tricyclic antidepressant toxicity case 2 continued (K19)	98/122, 80.3	89/100, 89.0	82/93, 88.2	0.127
IV sodium bicarbonate therapy in antidepressant toxicity (K20)	86/122, 70.5	83/100, 83.0	83/93, 89.2	0.002
Calcium channel antagonist toxicity case (K21)	92/122, 75.4	92/100, 92.0	77/93, 82.8	0.005
Valproic acid toxicity case (K22)	62/122, 50.8	77/100, 77.0	68/93, 73.1	< 0.001
Lithium toxicity case (K23)	26/122, 21.3	44/100, 44.0	28/93, 30.1	0.001
Paracetamol toxicity case 3 (K24)	112/122, 91.8	89/100, 89.0	85/93, 91.4	0.750
Australian toxinology: snake bite (K25)	47/120, 39.2	60/95, 63.2	62/90, 68.9	< 0.001
Australian toxinology: spider bite (K26)	39/120, 12.8	59/95, 62.1	59/90, 65.6	< 0.001
Australian toxinology: jelly fish sting (K27)	37/120, 30.8	41/95, 43.2	47/90, 52.2	0.007
Australian toxinology: snake bite management (K26)	83/120, 69.2	85/95, 89.5	79/90, 87.8	< 0.001

†Pearson's Chi Square

Results have demonstrated that knowledge and confidence vary considerably and are correlated. Both are enhanced by seniority, experience working in emergency medicine, and participation in educational activities. Clinicians scoring well on the knowledge score were justifiably more confident in their ability to manage toxicological presentations.

Overall, emergency clinicians performed well with over 80% passing the knowledge questions. More than 70% of clinicians correctly answered the topics of decontamination, poly-substance abuse management, use of oral activated charcoal, atypical antipsychotic toxicity, alcohol toxicity, paracetamol toxicity, TCA toxicity, and one of two calcium channel antagonist toxicity questions. Respondents generally performed poorly in topics of lithium toxicity and serotonin syndrome. This is concerning as psychotropic medications are some of the most commonly prescribed medications and they also comprise almost half of poisoning-related hospital admissions (1).

Increasing experience in emergency medicine significantly predicted knowledge. Education and attendance at workshops/conferences also significantly improved knowledge related to 12-lead ECGs, household product poisonings, oral activated charcoal, toxicities caused by paracetamol, valproic acid, TCA and lithium, as well as knowledge of serotonin syndrome; these are important toxicological topics in which emergency clinicians should be knowledgeable.

While confidence does not indicate competence, it may effect decisive management and reduce time to treatment, which is important in many presentations (6). A common example is the management protocol for paracetamol overdose, where

Table 5. Participants who agreed/strongly agreed to confidence statements according to receipt of formal toxicology education and participation in workshops and conferences

Item	Number/denominator, (Percentage)					
	Received formal toxicology education			Toxicology workshop or conference participation		
	Yes	No	P value*	Yes	No	P value*
I am confident in managing presentations requiring decontamination	143/2079, 69.1	69/116, 59.5	0.088	100/117, 85.5	112/206, 54.4	<.001
I am confident in recognizing toxidromes	139/208, 66.8	53/116, 45.7	< 0.001	83/117, 70.9	109/207, 52.7	0.001
I am confident in managing serotonin toxicity	137/208, 65.9	56/116, 48.3	0.002	82/117, 67.6	111/208, 52.8	0.005
I am confident in the interpretation of 12 lead ECG in Toxicology	155/208, 74.5	67/115, 58.3	0.004	94/117, 80.3	128/206, 62.1	0.001
I am confident in managing paediatric poisonings involving medications	111/206, 53.9	50/116, 43.1	0.081	70/116, 60.3	91/206, 44.2	0.007
I am confident in managing paediatric poisonings involving common household	117/207, 55.6	45/114, 39.5	0.004	73/117, 60.8	89/204, 43.4	0.002
I am confident in the use of extracorporeal elimination of drugs	60/206, 29.1	19/116, 16.4	0.011	36/117, 26.5	43/205, 20.5	0.059
I confident in using medications to treat specific toxicities	141/205, 68.8	59/113, 52.2	0.004	90/116, 77.6	110/202, 54.5	< 0.001
I am confident in managing sympathomimetic toxicity	116/205, 78.5	75/115, 65.8	0.016	96/116, 82.8	140/203, 69.0	0.008
I am confident in managing paracetamol poisoning	165/207, 79.7	90/116, 77.6	0.671	104 /117, 88.9	151/206, 73.3	0.001
I am confident in managing quetiapine poisoning	130/206, 63.1	56/116, 48.3	0.013	82/116, 70.7	104/206, 50.5	< 0.001
I am confident in managing all alcohol poisonings	134/206, 65.0	59/114, 51.8	0.023	79/117, 67.5	114/203, 56.2	0.057
I am confident in managing chloroquine poisoning	50/206, 24.3	27/115, 23.5	0.893	36/116, 31.0	41/205, 20.0	0.030
I am confident in managing calcium channel antagonist induced hypotension	140/207, 67.6	57/115, 49.6	0.002	87/117, 74.4	110/205, 53.7	< 0.001
I am confident in managing ethylene glycol poisoning	118/206, 57.3	52/114, 45.6	0.048	73/116, 62.9	97/204, 47.5	0.010
I am confident in managing cocaine toxicity	149/205, 72.7	64/116, 55.2	0.002	84/115, 73.0	129/206, 62.6	0.065
I am confident in the recognition of salicylate overdose	115/205, 56.1	53/114, 46.5	0.103	73/114, 64.0	95/205, 46.3	0.003

*Fischer's Exact Test

time is a critical factor is determining appropriateness of treatment and level of hepatic toxicity to be expected (1,6). This study showed emergency clinicians are both knowledgeable and confident in paracetamol toxicity management. Confidence was low in the use of extracorporeal elimination of drugs with only 25% of respondents being confident. This is not surprising given that this is a highly specialized area often only available in tertiary referral centers (17). Surprisingly, emergency clinicians' confidence was high in interpreting ECGs in toxicological presentations despite lack of knowledge. This is concerning as adverse cardiac events from drug overdoses represent a large proportion of significant life-threatening presentations in emergency situations (18).

Confidence and knowledge were moderately correlated, and knowledge was a significant predictor of confidence suggesting that the two are related. Both confidence and knowledge generally increased with receipt of formal education in toxicology and participation in relevant workshops. Specific toxicology education is an important issue in managing toxicology presentations appropriately and also in improving confidence. More qualified emergency clinicians are generally more knowledgeable and confident in toxicological presentations. Importantly, we have shown that rural and regional practicing clinicians are the most in need of toxicology education and support to facilitate this education.

LIMITATIONS

This study is not without limitations. Survey response rates cannot be reported due to the web-based recruitment.

Table 6. Participants who agreed/strongly agreed to confidence statements according to staff type.

Item	Staff Type Number/denominator, (Percentage)					
	CMO	EM Trainees	Consultant EM Physicians	Toxicologists	Other	P value
I am confident in managing presentations requiring decontamination	10/21, 47.6	73/139, 52.5‡	108/135, 80.0*	16/16, 100.0*	5/12, 41.7	< 0.001
I am confident in recognizing toxidromes*	9/21, 42.9	71/140, 50.7‡	96/135, 71.1*	13/16, 81.3*	3/12, 25.0	< 0.001
I am confident in managing serotonin toxicity	9/21, 42.9	70/140, 50.0‡	96/135, 71.1*	15/16 93.8*	3/12, 25.0‡	< 0.001
I am confident in the interpretation of 12 lead ECG in Toxicology*	12/21, 57.1	88/139, 63.3	105/135, 77.8*	13/16, 81.3	4/12, 33.3‡	0.002
I am confident in managing paediatric poisonings involving medications	7/20, 35.0	51/140, 36.4‡	82/135, 60.7*	15/15, 100.0*	6/12, 50.0	< 0.001
I am confident in managing paediatric poisonings involving common household*	10/20, 50.0	50/140, 35.7‡	83/134, 61.9*	15/16, 93.8*	4/ 11, 36.4	< 0.001
I am confident in the use of extracorporeal elimination of drugs	4/19, 21.1	28/140, 20.0	33/135, 24.4	13/16, 81.3*	1/12, 8.3	< 0.001†
I confident in using medications to treat specific toxicities*	7/18, 38.9‡	73/140, 52.1‡	102/132, 77.3*	14/16, 87.5*	4/12, 33.3‡	< 0.001
I am confident in managing sympathomimetic toxicity	12/19, 63.2	88/139, 63.3‡	114/ 134, 85.1*	15/15, 100.0*	7/12, 58.3	< 0.001†
I am confident in managing paracetamol poisoning*	15/20, 75.0	105/140, 75.0	113/135, 83.7	15/16, 93.8	7/12, 58.3	0.074†
I am confident in managing quetiapine poisoning*	5/20, 25.0‡	73/140, 52.1	89/134, 66.4	14/16, 87.5	5/12, 41.7	< 0.001
I am confident in managing all alcohol poisonings	8/19, 42.1	74/138, 53.6‡	91/135, 67.4*	15/16, 93.8*	5/12, 41.7	0.002
I am confident in managing chloroquine poisoning*	4/20, 20.0	24/139, 17.3‡	32/134, 23.9	12/16, 75.0*	5/12, 41.7	< 0.001†
I am confident in managing calcium channel antagonist induced hypotension	11/20, 55.0	73/140, 52.1‡	95/135, 70.4*	14/16, 87.5*	4/11, 36.4	0.002
I am confident in managing ethylene glycol poisoning*	10/20, 50.0	60/137, 43.8‡	81/135, 60.0*	13/16, 81.3*	6/12, 50.0	0.014
I am confident in managing cocaine toxicity	11/20, 55.0	82/140, 58.6‡	100/134, 74.6*	14/15, 93.3*	6/12, 50.0	0.004
I am confident in the recognition of salicylate overdose*	9/20, 45.0	56/139, 40.3‡	87/134, 64.9*	11/14, 78.6*	5/12, 41.7	< 0.001

†Test of significance violated assumption of chi square resulting in invalid test.
‡ Denotes significantly under-represented compared to other groups (according to adjusted standardised residuals)
* Denotes significantly over-represented compared to other groups (according to adjusted standardised residuals)

Selection bias was minimized by recruiting respondents in two methods: an online survey distributed via an ACEM Bulletin or via internet. Direct recruitment was not utilized, reducing the potential for selection bias however this may have impacted the overall number of respondents as this assumed that emergency clinicians readily accessed the internet. We cannot exclude the possibility of responder bias; those more interested in toxicological emergencies may have been more likely to participate. This may have produced an overestimate of knowledge and confidence of respondents.

The sample size was below that anticipated resulting in under powering for some analyses. This may have produced type 2 errors, the failure to reject the false null hypothesis. Additionally, the large number of analyses undertaken may have inflated the likelihood of making a type 1 error due to chance.

We attempted to minimize measurement bias by establishing the surveys face validity and content validity, given the absence of a relevant, previously validated tool. Additionally, we undertook further validation of the internal consistency of the knowledge and confidence components. Although the MCWs comprising the knowledge assessment in this survey were reviewed by several ED consultants and registrars it was not an exhaustive examination of toxicological emergencies, assessing just a few key presentations, and therefore may not extrapolate well to other toxicological emergencies not included in the survey.

We did not instruct participants to avoid consulting educational materials to improve performance. The anonymous nature of the survey, however, may have minimized any such Hawthorne Effect.

While the number of toxicologists completing the survey was low, this probably reflected the real world situation of very low numbers of such specialists in practice.

CONCLUSION

The toxicological knowledge and confidence of emergency clinicians is varied, yet correlated. Emergency medicine training programs should consider the benefit of expanding toxicological education, including emphasis on specific drug toxicities. Clinicians practicing in rural and regional hospitals would benefit greatly from the provision of further educational support, such as specific toxicology conferences and workshops.

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