

# Should We Be Using the Poisoning Severity Score?

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## Abstract

**Introduction** Despite the existence of a number of severity-of-illness classifications for other areas of medicine, toxicology research lacks a well-accepted method for assessing the severity of poisoning. The Poisoning Severity Score (PSS) was developed in the 1990s in Europe as a scoring system for poisonings reported to a poison center in order to describe a patient's most severe symptomatology. We reviewed the literature to describe how the PSS is utilized and describe its limitations.

**Discussion** We searched the medical literature in all languages using PUBMED, EMBASE, and SCOPUS from inception through August 2013 using predefined search terms. Out of 204 eligible publications, 40 met our criteria for inclusion in this review. There has been a paucity of published studies from

North America that used the PSS. In some cases, the PSS was misapplied or modified from standard scoring, making a bottom line appraisal of the validity or reliability of the original version of the instrument challenging. The PSS has several subjective criteria, is time consuming to score, and is likely to be of little use with some types of poisonings, limiting its clinical utility.

**Conclusion** The PSS was developed as a tool to document encounters with poisoned patients. However, it is used infrequently and, when applied, has been misused or modified from its original form. In its current form, it has limited clinical utility and likely cannot be broadly applied to many exposures due to their unique clinical circumstances. With better global collaboration among medical toxicologists, it is possible that a modified score could be developed for use clinically or as a research instrument.

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## Introduction

In 2014, the American Association of Poison Control Centers (AAPCC) reported 2,165,142 phone calls for possible human poisonings, which underrepresents total poisonings [1]. In 2004, the World Health Organization (WHO) reported 346,000 people worldwide died from unintentional poisoning [2]. Given the magnitude of the problem, the value of timely, appropriate, and cost-effective medical management of poisonings is critically important. The clinical severity of poisoning can range from asymptomatic to life-threatening depending on specifics related to the toxin and the timing of ingestion in relation to the availability of medical treatment. As such, the ability to predict the severity of toxicity, and therefore the patient's prognosis, is of critical significance. Clinical severity

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scores are used for medical conditions or applied to critically ill patients to predict the progression of their illness. They are also useful in research when comparing groups of patients. An example is the Glasgow Coma Scale (GCS). The GCS was first described in 1974 as a way to prognosticate the severity of a traumatic brain injury; it is an easy bedside tool that in addition to providing prognostic information now serves as a simple tool to communicate the severity of illness in a variety of conditions beyond traumatic brain injury [3].

A variety of static and dynamic severity scores are used in patient care and medical research. Static severity scores use the worst physiologic data points at a certain point in time, while dynamic severity scores collect data points over time. Examples of commonly used static scores include the Acute Physiology and Chronic Health Evaluation (APACHE II) and the Simplified Acute Physiology Score (SAPS). The Model for End-Stage Liver Disease Score (MELD) is a dynamic score while the Mortality Probability Model (MDM) can be static if it is only done at admission or dynamic if it is completed every 24 h [4]. There are also organ dysfunction scores such as the Multiple Organ Dysfunction Score (MODS) or Sepsis-Related Organ Failure Assessment (SOFA) which aim to trend overall organ dysfunction as it relates to morbidity and mortality [4]. Some of these scores have been applied to poisonings such as organophosphates [5–8] and paraquat [9].

The Poisoning Severity Score (PSS) was developed between 1990 and 1994 by the European Association of Poisons Centres and Clinical Toxicologists (EAPCCT), the International Programme on Chemical Safety (IPCS), and the Commission of the European Union to provide a simple and reliable scoring system to describe poisonings and define their severity [10]. The PSS uses a collection of clinical signs and symptoms to give a score of 0 to 4. The score is applied according to the patient's most severe clinical effects, regardless of the timing of those effects. It is not meant to provide prognostic information. A score of 0 equates to being asymptomatic, 1 is minor, 2 is moderate, 3 is severe, and 4 is given if the patient dies. As such, all patients that die should only receive a score of 4.

The PSS has been applied to a wide range of poisonings including hydrocarbons [11], organophosphates [5, 6, 12], antipsychotics [13, 14], and envenomations [15]. However, the PSS includes a large number of data points from 12 different organ systems and multiple subjective variables such as “mild hemolysis,” “mild hypotension,” and “prolonged coughing,” which decrease its inter-rater reliability. Given these significant limitations, we are skeptical that the PSS, in its present form, can reliably be used as a research or clinical tool. We also wonder if it is possible for a single scoring system to accurately predict outcomes in all toxic exposures given the wide variation and breadth of human poisonings and envenomations. We aim to review the literature to obtain a better understanding of how the PSS is utilized, determine if it is applied correctly, and describe its limitations.

## Methods

We searched the medical literature in all languages using PUBMED, EMBASE, and SCOPUS from inception through August 2013 applying search terms “poison severity score” or “toxicology severity score” or “toxicology score” or “toxicologic score” or “toxicologic scoring system” or “overdose scoring system” or “toxicology scoring system” or “overdose severity score” or “toxic scores overdose” or “poisoning severity score.” EMBASE was only searched with the term “poisoning severity score” due to the large number of publications returned with the other search strategies. The strategy returned a total of 2564 articles. Some articles were identified on more than one search. One of the authors reviewed the titles of the 2564 articles identified by the search. Based on the title, the abstract of any relevant article was reviewed. If the “Poisoning Severity Score” was included in the abstract, the publication was included for review.

Our search identified 204 publications of which 141 were abstracts only and 1 was a letter to the editor, all of which were excluded. Of the remaining 62 publications, 23 were only available in foreign languages; one was successfully translated. Attempts to translate the remaining foreign language articles were unsuccessful so the manuscripts were excluded, leaving 40 for review. The reference lists of all 40 manuscripts were reviewed for additional references but only returned two new abstracts, both of which were excluded.

## The Original Publications

In 1990, The EAPCCT convened a working group to develop a scoring system to standardize the evaluation of poisoned patients [16]. The group proposed two schemes: a detailed clinical scheme referred to as the TOXscore and a simplified version called the PhoneTOXscore, which was evaluated in a small pilot study and later renamed the PSS. After being renamed, the finalized version was published in 1998 as part of a two-phase trial originally involving 14 poison centers [10].

The initial phase included 14 poison centers from different parts of the world, included but not limited to Turkey, New Zealand, France, Toronto, and Uruguay; no sites from the USA were included. Each of the participating poison centers submitted 25–30 cases (convenience sample), which were summarized on a standardized form. A total of 371 cases were collected and redistributed to each site.

The 14 sites produced 5194 scores ( $14 \times 371$ ). Staff members at each site scored each of the cases. The percentage of times each of the centers assigned a case the same score was referred to as the concordance. Acceptable concordance was defined as 70% (10/14 centers with the same score). For example, there were 55 different cases of poisoning from

corrosives. For 12 cases, the concordance between centers was 50–69%; for 18 cases, it was 70–90%; and for 25 cases, it was >90%, for an overall acceptable concordance of 78% for corrosives. Overall, concordance ranged from 55% to 81% for all categories for an overall average of 72%.

After the results from phase 1 were analyzed, the scoring system was revised with “minor modifications” that were not specified. An additional three centers were included; however, these new centers did not submit any new cases. The same 371 cases were distributed to each of the 17 centers for scoring using the new system. Results were again analyzed between centers and acceptable concordance improved from 72% to 80%.

Even though the PSS was not intended as a prognostic score, the Birmingham Centre of the United Kingdom National Poisons Information Service (NPIS) published a validation study assessing the prognostic utility of the PSS in 1998 [17]. NPIS scored 718 consecutive inquiries made to the center. Cases were scored following the initial contact with NPIS. Of the 718 inquiries, 397 had a score of 0 (55.3%), 225 had a score of 1 (33.3%), 71 had a score of 2 (9.9%), and 25 had a score of 3 (3.5%). No patients were initially given a score of 4. The center then made a follow-up call 12–24 h after the initial contact and continued follow-up until the patient recovered or died; during follow-up, the PSS was scored again. Follow-up was completed for 638 cases (89%). Follow-up was obtained for 548 of 622 patients (88%) that originally had a PSS of 0 or 1; at follow-up, five patients developed a PSS of 2 but did not deteriorate further. Six patients that originally were scored as a PSS 2 received a score of 3 at follow-up. Five patients died and each were originally given a PSS of either 2 or 3. The authors concluded that the PSS is a simple and reliable system for describing a poisoning, describing its ultimate severity, and identifying the most severe cases.

### Articles Incorporating the Poisoning Severity Score

Forty manuscripts were reviewed (Table 1). Foreign language manuscripts that could not be translated and were excluded were published in China, Poland, France, Turkey, Belgium, Slovakia, Germany, Hungary, and Sweden. One manuscript from Hungary was translated into English and included in the review. Twenty-two of the studies correctly used the PSS. One study included the PSS in the abstract but not in the body of the manuscript so it is not clear how it was used [27]. Another study only mentioned that a  $PSS \leq 2$  was an independent prognostic factor but offered no other information regarding how the PSS was used [23]. Seven articles used the PSS in a unique way such as comparing it to another severity score. The remaining articles either misapplied the PSS or modified the PSS. Some articles are included in more than one category. For instance, the authors used the PSS in a unique way but

also used the score incorrectly or misapplied it. The review divides the articles into those that used the score correctly, those that used it in a unique way, and those that used it incorrectly or modified it. Table 1 includes a brief review of each manuscript with key critiques of how the PSS was incorporated in each article. For an in-depth review of each manuscript, please see the [online supplement](#).

### Studies that Properly Incorporated the Poisoning Severity Score

Many studies correctly applied the PSS [15, 18, 19, 21, 25, 31, 33, 35, 39–41, 44, 46, 47]. The score was included in these studies to describe the severity of illness. In some cases, it was used in a dynamic fashion as opposed to a static score. These articles are not included in this section as the PSS was misapplied even though it was calculated correctly. In many of the studies, the PSS was reported along with clinical and demographic data such as age, sex, or laboratory values. The studies were mostly from different authors and took place in a wide variety of locations. This indicates that the scoring system can be properly used in a wide variety of exposures and by authors not originally involved in developing the PSS. Two authors used the PSS correctly in multiple studies [7, 15, 24, 39]. Interestingly, four other authors used the PSS correctly in one study but then misapplied the PSS in a second study [25, 26, 30, 45, 47, 48]. If the PSS were demonstrated to be a useful research tool, it could be used to compare groups of patients such as occurred in these studies.

However to be considered useful, the PSS must do more than just be applied correctly. In most of the included studies, the PSS was incorporated as just another piece of clinical information, just like the patient’s age or sex. There are simpler ways to communicate severity of illness that do not require learning a new system, especially one as complex as the PSS. A few studies attempted to determine if other variables could predict the severity of an exposure by comparing them to the patient’s PSS. This included correlating CO levels [41], bicarbonate concentrations [40], and blood glucose concentrations [38] with the patient’s PSS. One author attempted to use the PSS to determine if intentional exposures caused more severe poisonings than accidental exposures [33]. It is not apparent that the PSS added anything to these manuscripts’ results or conclusions. In many of these studies, it would be easier for the reader to understand if the authors used a simpler system or excluded the PSS altogether. This is especially true given that most physicians are not familiar with the PSS so do not know how to interpret it. Stating that a patient has a PSS of 2 likely has much less meaning to another physician than when a colleague states a patient has a GCS of 5. Two other studies either completely excluded the PSS in the body of the manuscript or only mentioned that a  $PSS \leq 2$  was an

**Table 1** Manuscripts including the Poisoning Severity Score

Manuscript	Exposure and population	PSS breakdown
Abahussain and Ball [18]; Kuwait, 2010	Chemical or pharmaceutical poisoning in children <12 Rather than incorporating the PSS, it would be clearer to state that over 95% of patients developed minimal or no symptoms. Combined PSS of 2 and 3	978: 578 364 34 0
Adams et al. [19]; England, 2010	Accidental pesticide exposures called in to the National Poisons Information service Authors made multiple modifications to equate the PSS with another questionnaire. Given all the modifications, may have been easier to have everyone only use the questionnaire. Combined PSS of 2 and 3 and reported enquirers and SPI results, respectively	1284:– 1138/1247 – –
Akdur et al. [5]; Turkey, 2010	Patients with organophosphate poisoning presenting to the emergency department Modified the PSS. Authors claimed that both the PSS and GCS were effective tools as those patients with a PSS of 4 had significantly lower GCS scores (mean = 4.7; $p < 0.5$ )	54:0 32 6 13 3
Bucaretschi et al. [20]; Brazil, 2012	Exposures to rodenticides with acetylcholinesterase inhibitors called into the poison center Modified PSS by including treatments when deriving the score	76:4 9 27 33 3
Caldas et al. [21]; Brazil, 2008	Pesticide exposures reported to the Center of Toxicology and Assistance of the Federal District It would be simpler and clearer to list the muscarinic symptoms or bleeding in patients exposed to organophosphates or coumarins, respectively, instead of using the PSS to demonstrate the severity of illness	709:162 342 97 90 18
Cevik et al. [22]; Turkey, 2006	Patients with carbon monoxide toxicity presenting to the University Medical Center No patients were given a PSS of 4, yet 6 died. Moderate correlation between CO level and PSS ( $r = 0.329$ , $p < 0.001$ )	182:2 134 28 18 0
Charra et al. [23]; Morocco, 2013	Any intoxicated patient >14 years old admitted to the intensive care unit A PSS $\leq 2$ was associated with a good prognosis (OR 0.11, CI 0.049–0.237, $p < 0.001$ )	214:– – – – –
Churi et al. [7]; India, 2012	All patients exposed to organophosphates presenting to the emergency department The authors found a significant association ( $p < 0.001$ ) between the PSS, GCS, APACHE II, and predicted mortality. They do not state which score was the best. Or the one they preferred using	136:0 83 36 10 7
Churi et al. [24]; India, 2012	All patients admitted following a poisoning or envenomation There was a moderate correlation between the GCS and PSS ( $r = 0.51$ , $p < 0.001$ ). There was also a significant association between clinical outcomes, the GCS, and the PSS	212:0 165 42 1 4
Davies, Eddleston, and Buckley [6]; Sri Lanka, 2008	All patients with an acute, solitary exposure to an organophosphate Authors modified the PSS and 184 deaths were scored as a PSS of 1–3. A PSS of 2 at admission had a sensitivity of 0.78 and specificity of 0.79 for predicting death. Authors also concluded that the GCS was as accurate as the PSS in predicting mortality (AUC 0.84 vs. 0.81)	1365:0 973 138 254 0
Deguigne et al. [25]; France, 2011	Metam sodium exposures reported to the Poisons and Toxicovigilance Centre As it was not clear how the authors scored the PSS, it would be clearer to state that 99% of patients had minimal or no symptoms. PSS of 0 and 1 and PSS of 3 and 4 were combined	102:101 0 1
Deguigne et al. [26]; France, 2013	Patients with acute-on-chronic lithium intoxication reported to the Toxic Exposure Surveillance System The PSS confirmed what is already intuitive, that a lower dose and a lower lithium concentration are associated with less severe symptomatology. PSS of 0 and 1 and PSS of 2–4 were combined	59:29 30
Eizadi-Mood et al. [27]; Iran, 2012	All poisoned patients presenting with a CPK > 250 IU/L The PSS was calculated but the results were not reported. No explanation was given for this so it is unclear what if anything the PSS contributed to the manuscript	80:– – – – –
El Salam et al. [11]; Egypt, 2011	Patient without chronic cardiac, pulmonary, or renal disease admitted within 24 h of a hydrocarbon ingestion They correlated the PSS with final outcome, ICU admission, and intubation. Authors recommended patients with PSS $\geq 2$ are admitted to the ICU. They concluded that the PSS was useful in predicting outcomes.	100:32 50 14 4 0
Eyer et al. [28]; Germany, 2011	Patients admitted to the intensive care unit following a solitary quetiapine overdose with a PSS of 2 or 3 Used the PSS to determine which patients to include. Only included patients with a PSS $\geq 2$	20:0 0 9 10 1
Giannini et al. [29]; Italy, 2007	All patients with amatoxin poisoning The PSS was modified by stratifying the scores using transaminase concentrations. Two patients that died were scored a PSS of 3	111:0 62 18 31 0
		33:– – – – –

**Table 1** (continued)

Manuscript	Exposure and population	PSS breakdown
Hrabetz et al. [12]; Germany, 2013	All patients admitted to the intensive care unit treated for cholinergic toxicity following an organophosphate exposure The authors did not include a breakdown of the PSS and rationale for this decision is not included. The authors included the PSS, GCS, APACHE II, and SOFA but did not compare the scores	
Hunfeld et al. [13]; Netherlands, 2006	Patients reported to the pharmacy after an intentional quetiapine overdose The authors list specific symptoms as minor, moderate, or severe. What was included is not the complete list of symptoms in the PSS so the authors may have modified the PSS	14:0 6 5 3 0
Hung et al. [30]; Vietnam, 2008	All poisonings or toxic exposures admitted to the poison control center The authors misclassified the PSS as 21 patients died but only 1 was assigned a PSS of 4	1836:135 1214 298 188 1
Hung et al. [31]; Vietnam, 2009	All patients admitted to the intensive care unit following <i>Bungarus multicinctus</i> envenomations While it was reasonable to include a severity score, describing the frequency of interventions more transparently would better establish the severity of illness compared to using the PSS	60:0 3 0 50 4
Jimmink et al. [32]; Netherlands, 2008	All citalopram overdoses identified by the Central Hospital Pharmacy Laboratory The PSS was modified. Two fatalities were scored a PSS of 3	26:0 3 9 14 0
Jose et al. [33]; India, 2012	Children ≤18 years old admitted following a poisoning The PSS was used to triage patients. However, a shorter and less subjective list of signs or symptoms would more easily and rapidly triage patients	121:24 67 17 10 3
Karbaksh and Zandi [34]; Iran, 2008	Patients >60 years old following an acute poisoning PSS was misapplied as there were 35 fatalities but no patients scored a PSS of 4	299:16 76 156 50 0
Kuzelová et al. [35]; Slovakia, 2009	Children ≤18 years of age with alcohol intoxication The problem of adolescent ethanol consumption was effectively communicated by demonstrating the increase in BAC and admission rates between the 2 time periods without including the PSS	537:10 256 250 21 0
Lauterbach et al. [36]; Germany, 2005	Patients with hydrogen phosphide exposures reported to the poison center The follow-up rate was low, 48.3%, which is a significant limitation in using the PSS	188:55 70 17 7 2
Malina et al. [37]; Croatia and Hungary, 2010	All admitted patients following Balkan adder envenomations The authors modified the PSS. Fatalities were not recorded during part of the study, although one was included	54:5 24 12 12 1
Palenzona et al. [14]; Switzerland, 2004	Patients >16 years old with solitary acute olanzapine overdoses reported to the Swiss Toxicological Information Centre The authors may have modified the PSS, although this is not clear. There was a significant association between increasing olanzapine dose and PSS ( $p = 0.025$ ).	26:0 14 11 1 0
Sabzghabae et al. [38]; Iran, 2011	Non-diabetics >18 years of age following a suicide attempt with an agent not associated with hyperglycemia or hypoglycemia and that did not receive dextrose or glucocorticoids As opposed to correlating blood glucose concentrations with the PSS, it would be clearer to associate the glucose concentrations with pertinent outcomes such as respiratory failure or death	345:169 78 58 38 2
Sam et al. [8]; India, 2009	All patients presenting to the emergency department following organophosphate or carbamate exposures The authors modified the PSS. They did conclude that the GCS, APACHE II, PMR, and PSS were all useful scoring systems	71:1 3 20 37 10
Schaper et al. [15]; Germany and France, 2004	All patients with rattlesnake envenomations reported to poison centers in France or Germany Extreme pain, severe thrombocytopenia, and compartment syndrome are all criteria for a PSS of 3, although the clinical significance of an isolated lab abnormality is very different than the other 2 findings.	21:0 8 5 8 0
Schaper et al. [39]; Germany and France, 2009	Patients reported to any of 4 different poison centers following envenomations from exotic pets While the inclusion of a severity score was reasonable, stating the number of patients that developed certain symptoms or required specific interventions would be a more useful descriptor than the PSS	404:0 320 55 29 0
Seok et al. [40]; South Korea, 2012	Patients >18 years of age following an intentional ingestion of a chloracetanilide herbicide It would be easier to state that few patients had significant symptoms and that the elderly were more likely to be symptomatic than it was to correlate findings with PSS	35:17 10 5 2 1
Turedi et al. [41]; Turkey, 2011	All patients with CO > 2% admitted to the emergency department without ischemic disease, hepatic failure, or heart failure The authors found a significant correlation between carbon monoxide levels and the PSS at admission, but there was no correlation between the PSS and ischemia-modified albumin	37:0 22 10 1 0

**Table 1** (continued)

Manuscript	Exposure and population	PSS breakdown
Von Mach et al. [42]; Germany, 2004	All patients reported to the poison center following an insulin overdose Follow-up was only obtained in 46.9% of patients. Four patients that died were not scored a PSS of 4	160:27 59 40 34 0
Von Mach et al. [43]; Germany, 2006	All patients following an overdose of insulin, sulfonylureas, or biguanides reported to a regional poison center Follow-up was poor for all 3 types of exposures	626:27 59 40 34 0
Walter and Persson [44]; Sweden, 1999	Patients >10 years of age with toxic exposures following home or leisure activities An author was involved with the development of the PSS. Ninety percent of cases were scored a PSS of 0 or 1. The authors could just as easily have communicated the mildness of exposure by noting only 28% of cases required any medical care	1033:124 806 72 0 0
Williams et al. [45]; England, 2012	Inquiries made to the UK National Poisons Information Service following household product exposures Follow-up calls were obtained 4 h after original inquiry and were only successful in 55% of patients. As such, scoring may not accurately reflect the patient's most severe symptomatology. PSS misapplied in 2 patients that died	5939:4117 1638 75 9 0
Williams et al. [46]; England, 2012	Inquires made to the UK National Poisons Information Service following exposures to liquid detergent capsules The authors correctly used the PSS	647:382 243 10 2 0
Wong et al. [47]; Australia, 2010	All patients reported in the VEMD or VPIC following intentional overdose of an antidepressant The authors combined PSS of 0 and 1 and 2 and 3. It would be more useful to know how many patients developed certain adverse effects such as cardiotoxicity, seizures, or respiratory depression following a TCA overdose than knowing their PSS	1833:1715 118 0
Wong et al. [48]; Australia, 2012	Patients reported to the VPIC following hydrofluoric acid exposures All patients called into VPIC early had a PSS of 0 while most called in later had a PSS of 1 or 2. This study illustrates the problems with attempting to apply the PSS as a prognostic score based on initial symptoms rather than the most severe symptomatology	75:10 49 16 0 0

Key: Total patients: PSS 0|PSS 1|PSS2|PSS 3|PSS 4. It is noted in the table if the authors combined any categories. Due to missing or incomplete information, the amount of patients scored with the PSS does not always equal the total number of patients included in the study. Not all studies included a breakdown by PSS

*BAC* blood alcohol concentration, *CPK* creatine phosphokinase, *TCA* tricyclic antidepressant, *GCS* Glasgow Coma Scale, *APACHE* Acute Physiology and Chronic Health Evaluation, *SOFA* sequential organ failure assessment score, *PMR* predicted mortality rate, *VEMD* Victorian Emergency Minimum Dataset, *VPIC* Victorian Poisons Information Centre

independent prognostic factor [23, 27]. Whether these were oversights or evidence that the scoring system is not useful or valuable is unknown. While collecting data such as a patient's age or sex either prospectively or in a retrospective manner is relatively simple, calculating the PSS is cumbersome and is not worth including if it does not provide any additional, useful information other than what is already routinely and more easily collected.

### Studies Comparing the Poisoning Severity Score to Another Severity Score or Using the Poisoning Severity Score Uniquely

A few authors used the PSS in nontraditional, interesting, or unique ways. In some studies, the PSS was modified or misapplied or used in a dynamic fashion. However, they are included in this section due to how the PSS was incorporated.

Four studies compared the PSS to other severity scores. Two compared the PSS to the GCS [5, 24]; one to the GCS, APACHE II, and SAPS II [7]; and one to the GCS, predicted

mortality rate (PMR), and APACHE II [8]. Overall, the authors felt that all scores performed well, although this is certainly debatable. Churi et al. noted a moderate correlation between the PSS and GCS ( $r = 0.51$ ,  $p < 0.001$ ) [24]. Akdur also noted that patients with a PSS of 3 or 4 had a significantly lower GCS (mean 4.7) and so determined that both scores were effective tools [5]. However, both groups of authors concluded that while both were equally effective, the GCS was much easier to apply than the PSS. In a second paper by Churi et al., the authors do not state which scoring system was the best but concluded that the PSS, GCS, and APACHE II all predicted mortality well [7]. This would be expected with the PSS as only patients that died could get a score of 4. Sam et al. noted a significant negative linear relationship between the APACHE II, PMR, and PSS ( $r = -0.660$ ,  $r = -0.636$ , and  $r = -0.583$ , respectively;  $p < 0.001$ ) [8]. They also found significant linear correlations between the clinical outcome and the different scores: APACHE II ( $r = 0.347$ ,  $p = 0.003$ ), PMR ( $r = 0.419$ ,  $p < 0.001$ ), and PSS ( $r = 0.557$ ,  $p < 0.001$ ). They concluded that all four scores were useful in determining the severity of organophosphate poisonings. These studies should be praised for attempting to compare and validate the

clinical significance and use of the PSS. While it appears that the PSS performed well compared to other severity scores, two authors explicitly mention that it was more difficult to use than the GCS. As multiple authors found the PSS difficult to use, it makes us wonder if it would be simpler to incorporate a different severity score that performs just as well as, if not better, than the PSS. Even if the PSS performed as well as other scores, physicians are not familiar with it or how to interpret it which limits its utility.

However, not all authors draw similar conclusions. In a study by Peter et al. that was first available online in September 2013 (after the literature search was completed), they compared the APACHE II, Mortality Prediction Model II, SAPS II, and PSS in organophosphate poisoning [49]. They found that the area under the curve (AUC) for mortality was significantly higher for the APACHE II (0.77) and SAPS II (0.77) than for the PSS (0.67). Overall, the authors concluded that the PSS was a poorer discriminator and inferior to the other scoring systems, which is likely an appropriate conclusion.

The PSS includes a large number of variables, many of which are subjective. In comparison, scores such as the APACHE II only include 15 variables derived from basic laboratory values and vital signs, and an additional 16th variable, which is slightly subjective (severe organ system dysfunction or immunocompromised). This may partly explain why scoring systems such as the APACHE II are used more frequently than the PSS. Familiarity could also account for this as the APACHE II can be used with all patients but the PSS is only applicable in poisoned patients. However, the APACHE II was used in studies of poisoned patients instead of the PSS [50, 51]. If future research demonstrates that the PSS or a modified form of it was equal or superior to other severity scores and was easy to use, then it may be worth using clinically or incorporating into more studies. In addition, the introduction of more sophisticated electronic health records and data extraction tools, however, could make the PSS easier to use.

### Modification or Misapplication of the Poisoning Severity Score

Nearly half of the included studies (16/40) either modified or misapplied the PSS. There were 10 studies that used the complete PSS but misapplied it [6, 11, 28–30, 32, 34, 42, 43, 45]. The most common mistake noted in these studies was not accurately applying a PSS of 4, which is to be used for all deaths. For instance, Jimmink et al. misclassified two patients as a PSS of 3 who died [32]. These studies often scored patients who died as a PSS of 3. This could be due to scoring patients too early.

In nine studies, the PSS was modified [5, 6, 8, 13, 14, 20, 29, 32, 37]. Generally, the modification simplified the PSS. Signs and symptoms were either grouped or, in some cases, were eliminated. For instance, Davies et al. modified the PSS by not including oxygen saturations, ECG findings, or laboratory data such as arterial blood gasses [6]. By modifying the PSS, the authors technically created a new scoring system invalidating the actual PSS. While some authors were exploring new applications of the PSS, this also suggests that the PSS as derived was potentially inadequate. Even if the score was used properly, it would not carry the same prognostic abilities as scores such as the GCS, which would still be a significant limitation. The multiple modifications and misapplications of the PSS may serve as further evidence that researchers do not find the scoring system to be useful and likely further explains its poor utilization.

### The Utility of the Poisoning Severity Score

Severity scoring systems are useful for both research and clinical purposes. For research, a severity score assists in making comparisons between groups of patients. Clinically, a severity score could assist in determining prognosis, need for admission, and place of admission (i.e., floor verse ICU). To be useful, a scoring system must be simple to use. Ideally, one should be able to simply place its variables into a smartphone application and derive the score at the patient's bedside. After completing this review, we found that the PSS was rather complex and, in comparison to other severity scores, was not as easy to use in poisoned patients [52, 53]. As such, we feel that the PSS has limited utility in either clinical use or research.

Scoring systems need to be reliable and have high degrees of inter-rater reliability. Scoring systems that use objective data such as laboratory values or hard numbers such as vital sign measurements and that use simple yes/no questions such as did a seizure occur are more likely to be reproducible. The PSS has multiple subjective terms such as frequent versus infrequent seizures. When more subjective information is included, severity scores will have lower inter-rater reliability. Even well-known and practiced scoring systems have been criticized for this. For instance, the GCS has objective values (eyes open versus closed) but also more subjective findings as well (inappropriate versus confused speech). While it is used in hospitals every day, some studies have shown poor inter-rater reliability [54, 55]. If inter-rater reliability is questioned in commonly used scores, we worry that the PSS would be greatly limited as it is used less often. While it appears that a few toxicologists and physicians do use the PSS for research, albeit not a large number given how infrequently we found it included in studies, it is not clear if they use it clinically. At least anecdotally, it does not appear that most physicians are

incorporating the PSS into their clinical practice, which may indicate that it is not very useful or is difficult to use.

The PSS incorporates 12 different categories based on the organ system affected with each category including a large number of variables. In comparison, other scoring systems incorporate far fewer variables and categories or the practitioner only has to enter a known, commonly available laboratory value, making the scoring systems easier to remember and use. Some scoring systems such as the APACHE II are more complex in that they incorporate many variables. However, the practitioner only has to enter a few specific numbers such as the patient's age, heart rate, or potassium. Scores such as these can easily be placed into a computerized or smartphone application or even abstracted by an electronic health record, which likely increases their utilization and makes them easy to use. Based on the breadth of information incorporated into the PSS, it is not reasonable to remember the complete score. While a computerized application would solve that issue, the application would be long and cumbersome and, therefore, would be unlikely to be used. For researchers, variables used in other scoring systems (e.g., APACHE, SAPS) can easily be derived from the chart. This is not true for the PSS as variables such as vomiting, diarrhea, coughing, and isolated extrasystoles are not always documented in the chart or are not documented in enough detail to be accurately scored. Still, application of advanced data extraction tools to the electronic health record could simplify or complement the overall PSS calculation. In addition, a medical record could be constructed in advance so that recording data related to poisonings was easier.

An underlying question not directly answered in this review but very relevant to this topic, is whether it is even reasonable to expect one scoring system to be both easy to use and to perform well in all poisoned patients. This was one goal of reviewing this literature since if the PSS was found to be a useful severity score, then more physicians or researchers should use it. However, we do not believe this to be the case. While we commend the original authors of the PSS for a very worthy effort, we wonder if their goal is practical. If not, then any score developed exclusively for poisoned patients will be either poorly utilized or commonly modified or misapplied. Medical toxicologists evaluate patients that are poisoned by many substances (e.g., medications, illicit drugs, plants, and animals), each with their own, unique pathophysiology. While patients may develop similar signs and symptoms from many different exposures, their significance changes in the context of the exposure. For instance, the nausea and vomiting that occurs after an overdose of ibuprofen carries very different implications than nausea and vomiting that develops after eating an unknown mushroom. In addition, many poisoned patients present with altered mental status or lethargy, but the significance of this varies greatly depending on the specific exposure. Patients with an isolated benzodiazepine overdose

can present with diminished mental status but are unlikely to experience any significant complications or require invasive treatments. However, the significance, prognosis, and treatment implications are very different if the lethargy or altered mental status is due to either large amounts of opioids or from acute salicylism. In comparison if a patient with a head injury presents with a very low GCS, no matter the underlying injury, it can be expected that the patient will have a poor prognosis and require multiple resources. Of course, this is a limitation of using even well-known scoring systems in toxicology patients. While a GCS of 3 in a patient with a head injury is an incredibly poor prognostic sign, a patient with a GCS of 3 after an overdose of benzodiazepines could be expected to do very well. As such, it may be best to either develop a scoring system that is specific to an exposure (e.g., the Snakebite Severity Score) or to use a scoring system that is already known to perform well in sick patients, even if it is not validated in poisoned patients and may not be perfect in all poisonings. Developing exposure-specific scores would likely make the scoring systems more reliable and easier to use. However, they would not be externally valid to other poisonings and would lead to the development of multiple severity scores.

### Locations of Studies that Incorporated the PSS

The included studies took place in a variety of locations ranging from Europe to the Middle East to Asia. Noticeably, none of the studies were completed in North America and only two were from South America. It could be argued that this is not surprising as the score was mainly derived in Europe. Therefore, it could be expected that researchers from those areas would be more familiar with it and, therefore, more likely to use it. However, centers from North and South America were involved in the original derivation of the score. In addition, the PSS was published in *Clinical Toxicology*. Since its initial publication, multiple abstracts presented at the North American Clinical Congress of Toxicology have included the PSS [55–60]. In addition, researchers from countries that were not part of the original derivation published studies that incorporated the PSS.

Since its original publication, advances in technology have greatly increased the ease in which information is disseminated and shared. Increased access to high-speed internet and portable internet-ready devices (e.g., smartphones, tablets), in addition to the development of blogs, podcasts, and other social media applications, has made sharing of information easier and improved knowledge translation. As such, it is unlikely that the paucity of studies from the USA is solely due to lack of awareness of the PSS. We believe the omission serves as evidence that many North American medical toxicologists



do not perceive the PSS to be useful or find it difficult to use and, therefore, do not include it in their research.

### Limitations of the Review

While multiple search terms were used in multiple databases, it is possible that we missed papers that included the PSS. It is possible that we missed other manuscripts that had they been included, may have changed our findings and conclusions, although we believe this to be unlikely. Even if studies were accidentally omitted, we do not believe that would change our conclusions regarding the utility of the score and its ease of use for either clinical or research purposes. While we cannot be sure that we did not miss any additional manuscripts, we believe that, if we did miss other studies, it would be unlikely that the missing studies would only be from North or South American countries. In addition, almost all of the manuscripts written in languages other than English were excluded. Had we been able to translate more of the foreign manuscripts or found additional articles, our conclusions regarding misapplying or modifying the PSS or how it was used in comparison to other severity scores may have changed. However as none of the foreign language articles were from North or South America, their inclusion would have skewed our findings even further regarding the origin of the manuscripts. As such, we believe that the pattern of very few researchers in North or South America using the PSS as compared to Europe is real.

### Conclusion

The PSS is infrequently used in North and South America. When used, it is frequently modified or misapplied making it difficult to assess its accuracy or utility. The PSS is not the ideal score to be used for all global toxicologic exposures secondary to the difficulty in using it, poor inter-rater reliability, and its length. Further collaborative research could be directed at developing a severity scoring system that could be applied in all poisoned patients. However, this could suffer the same limitations as the PSS. Another option would be to develop exposure-specific poisoning scores. However, these scores would be limited in their generalizability and likely limit their adaptability.

### Compliance with Ethical Standards

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**Conflicts of Interest** None

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