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Poison center consultation reduces hospital length of stay

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ABSTRACT

Context: Prior studies have observed shorter lengths of stay when practitioners consult a US poison control center (PCC) regarding hospitalized toxicology patients, but the most recent study used data from 2010. Since then, the implementation of the Affordable Care Act, a trend toward shorter hospitalizations and substantial adjustments in hospital charges have occurred.

Methods: This is a retrospective study of administrative hospital data and poison center data obtained from the Wisconsin Hospital Association and Wisconsin Poison Center for patients treated from 2010 to 2017. Stratified analysis was used to investigate the potential effects of PCC consultation on hospitalization. Univariate and multivariable regression analysis was used to characterize which factors were associated with an increased rate of PCC consultation.

Discussion: 127,224 hospitalized cases were found, of which 44,628 were entered into a stratified hospital charge and length of stay analysis. PCC consultation was associated with an 11.6 h (95% CI 10.4–13.0 h) shorter mean length of stay overall, with children aged 0–6 having a larger reduction of 1.18 days. While total charges were higher by \$600 in PCC consultation cases in the overall analysis (95% CI \$390–\$777), mean charges in patients aged 0–6 were \$6695 lower when the PCC was consulted. PCC consultation was more likely to occur in cases involving children and adolescents, intentional overdoses (versus accidental or unknown intent), and women.

Conclusions: Our findings suggest that PCC consultation should be encouraged to potentially shorten hospitalizations of poisoned patients, and for pediatric patients in particular. Intentionality and demographic factors affect the rate of PCC consultation for overdose, but the nature of these relationships is unclear.

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Poisoning; overdose; length of stay; poison center

Introduction

Poison control centers (PCCs) remain a vital and frequently utilized component of the public health infrastructure in the US, with over 2.1 million exposure cases logged in 2020 [1]. PCC consultation has previously been shown to benefit patients with poisoning exposure and the healthcare system at large via the provision of home care guidance, hospital-based treatment recommendations, and surveillance and monitoring of poisoning trends in the population [2]. Specific guidance provided to hospitals that care for poisoned patients includes advice regarding administration of antidotal and other therapy, suggested duration of observation for various exposures, and other guidance regarding resource utilization (e.g., laboratory, imaging, and otherwise). The measurable economic impact of PCCs notably includes reduced unnecessary emergency department utilization [3–5]. In addition, multiple previous studies have shown decreased hospital length of stay and charges in cases where the poison center is consulted by staff caring for patients as compared to cases where a poison center is not involved in hospital care [6,7]. However, prior studies on the impact of PCCs on hospital charges and length of stay addressed

patients hospitalized more than a decade ago in a healthcare landscape which is constantly changing.

PCCs manage an ever-greater number of high complexity intentional cases, as compared to unintentional cases [1,8]. In the time since the most recent data were published [7], mortality from overdose deaths, driven principally by unintentional opioid overdoses, rose sharply to 92,511 in 2020 [9]. In terms of general hospital-based healthcare, the average length of hospitalization has been increasing in recent years, though fewer patients are hospitalized. The per capita cost and the cost per hospitalization both continue to increase [10]. Therefore, in the setting of continuously evolving poisoning trends and hospital utilization, we sought to re-evaluate the effects of PCC consultation on hospital length of stay and charges. Secondly, we sought to characterize PCC utilization patterns by determining which types of poisonings are most likely to result in PCC consultation.

Methods

This is a retrospective cohort study of patients treated for poisonings in Wisconsin hospitals over an 8-year period from January 2010 through December 2017 (8 years). Inpatient

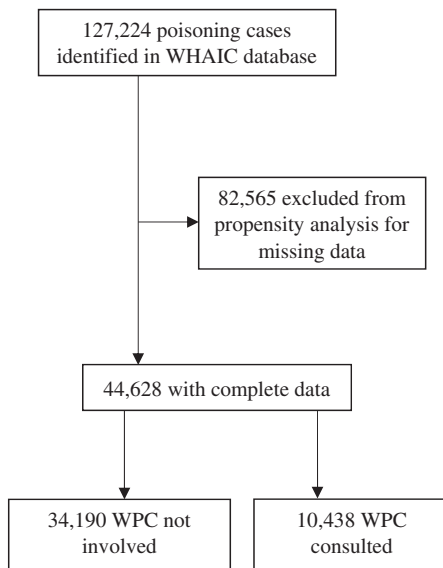


Figure 1. Strobe diagram.

data on hospitalizations collected from the Wisconsin Hospital Association Information Center (WHAIC) were obtained and processed through an unrestricted grant to the Wisconsin Department of Health Services' Office of Health Informatics in the Division of Public Health (DPH). These data are generated by Wisconsin member hospitals and collected by the Wisconsin Hospital Association (WHA) for the purpose of complying with Chapter 153 of Wisconsin Statutes. Collected data elements are those used for filing inpatient billing claims (though not Emergency Department billing claims). They include demographic information, discharge status, primary payer, diagnosis-related group (DRG), and average length of stay (ALOS), in addition to hospital charges. Inclusion criteria were patients treated for poisoning identified via discharge ICD-9 and ICD-10 codes in WHA databases (see Appendix 1 for ICD codes used). Exclusion criteria were cases treated for other pharmacologically related conditions, such as adverse drug events, and those with incomplete data. The Wisconsin Poison Center case database was queried to identify matching cases. Cases were matched and chart linkage made using dates of service, name, and address of patient. Cases successfully linked were classified as "WPC consulted" and cases not successfully linked were classified as "WPC not consulted".

Stratified matching on basis of age groups and poisoning intent was performed between "WPC consulted" and "WPC not consulted" groups. After matching, hospital length of stay, in days, was compared between groups and overall, via a negative binomial model and the incidence rate ratio was calculated as the exponential of the regression coefficient for the WPC consulted group. Hospital charges (log-transformed) were compared via the Student's *t*-test and linear regression modeling. Mortality was compared using logistic regression. We also performed a sensitivity analysis of length of stay and charge effects of WPC Consultation wherein gender was stratified in addition to age and intentionality.

Logistic regression was also used to determine which variables were associated with WPC consultation (i.e., "WPC

Table 1. Cohort demographics – number of cases in each age/intention group.

Age and intent	WPC consulted	WPC not consulted
0–6 years (N = 963)	675	288
Self-inflicted (N = 4)	3	1
Unintentional (N = 945)	662	283
Undetermined (N = 14)	10	4
7–12 years (N = 242)	120	122
Self-inflicted (N = 141)	57	84
Unintentional (N = 91)	57	34
Undetermined (N = 10)	6	4
13–18 years (N = 4483)	2144	2339
Self-inflicted (N = 3769)	1843	1926
Unintentional (N = 529)	220	309
Undetermined (N = 185)	81	104
>18 years (N = 38,940)	7499	31,441
Self-inflicted (N = 20,678)	5800	14,968
Unintentional (N = 15,518)	1440	14,078
Undetermined (N = 2744)	349	2395
All ages (N = 44,628)	10,438	34,190
Self-inflicted (N = 24,592)	7613	16,979
Unintentional (N = 17,083)	2379	14,704
Undetermined (N = 2946)	443	2507

Consulted"). Matching was done using SAS software. Statistical analysis was performed using R 3.6.3. Statistical significance was determined at an alpha value of 0.05. This study was performed in compliance with STROBE guidelines, and was approved by the Children's Wisconsin IRB, protocol #1155602-3.

Results

In total, 127,224 cases were identified from the WHAIC database over an 8-year period using ICD-9 and ICD-10 diagnostic codes for poisonings. The median age was 46 years (IQR 33–58), the median length of stay was 3 days (IQR 2–4), and the median hospital charge was \$11,122 (IQR \$6565–\$20288). Of these cases, 82,565 (65%) were excluded because of missing data. Of the 44,628 remaining cases, 26,015 (58%) were female and 18,613 (42%) were male; 10,438 (23%) were linked to the WPC case database (see Figure 1). Demographics of WPC consulted vs. WPC not consulted groups are presented in Table 1.

Length of stay is presented in Table 2. Overall, the "WPC Consulted" group was associated with an overall incidence rate ratio of 0.839 (95% CI 0.821–0.858), indicating a ~16% shorter length of stay in this group as compared to the "WPC not consulted" group (e.g., $1 - 0.839 = 0.161$). This equates to a mean reduction of 11.6 h (95% CI 10.2–12.9 h). The hospital charge analysis is given in Table 3. After adjusting for age group and intention class, the charges in the "WPC Consulted" group were higher, with linear regression showing a beta value of 0.0525 (95% CI 0.0351–0.0698). This equates to a 5.39% (95% CI: 3.57%–6.91%) increase in hospital charge in the "WPC consulted" group. For the outcome of mortality, after adjusting for age group, sex, and intention, WPC consultation was not associated with mortality (the odds ratio for death was 1.25 (95% CI 0.933–1.6751), *p*-value = 0.134). In the 0–6 year-old age group, 98% of the matched cases were unintentional. In this age and intention class, the association between WPC consultation and decreased length of stay was larger, with a LOS reduction of 1.18 days. There

Table 2. Mean length of stay (days), WPC not involved versus WPC consulted charts by age group and intention.

Age and intention	WPC consulted	WPC not consulted
0–6 years		
Self-Inflicted	2	3
Unintentional	1.67	2.85
Undetermined	1.4	5
7–12 years		
Self-Inflicted	1.93	3.74
Unintentional	1.16	1.97
Undetermined	1.17	4
13–18 years		
Self-Inflicted	2.11	3.45
Unintentional	1.51	2.03
Undetermined	2.14	2.22
>18 years		
Self-Inflicted	2.89	3.16
Unintentional	3.21	2.74
Undetermined	2.58	3.03

Table 3. Mean hospital charges (USD), WPC not involved versus WPC consulted charts by age group and intention.

Age and intention	WPC consulted	WPC not consulted
0–6 years		
Self-Inflicted	10,200	7221
Unintentional	11,837	18,532
Undetermined	10,994	34,596
7–12 years		
Self-Inflicted	15,394	12,171
Unintentional	10,072	17,073
Undetermined	21,911	16,182
13–18 years		
Self-Inflicted	12,546	11,110
Unintentional	11,353	14,950
Undetermined	21,129	10,534
>18 years		
Self-Inflicted	16,547	14,544
Unintentional	21,299	22,807
Undetermined	18,337	20,469

were also substantially lower hospital charges for admission in the “WPC Consulted” group – \$6695 less than the “WPC not consulted” group. In older pediatric patients (7–12 years, 13–18 years), similar to 0–6-year-old patients, lower hospital charges in the “WPC Consulted” group were also consistently observed within the “Unintentional” exposure classification. However, unlike the 0–6 age group, “Self-Inflicted” was more common than “Unintentional” intention class and charges were higher in the “Self-Inflicted” and “Undetermined” cases as compared to “WPC not consulted” group, so the overall charge reduction was much lower. The sensitivity analysis wherein we stratified cases by gender in addition to age and intentionality produced similar results to the primary analysis.

The logistic regression analysis results for the likelihood of poison center consultation, as per demographic and intentionality data, revealed several statistically significant associations as described in Table 4. WPC consultation was more likely to occur in pediatric and adolescent patients, intentional overdoses (versus accidental or unknown), and in women. In the multivariable analysis, the youngest age group (0–6 years) had the strongest association with WPC consultations (aOR 12.9, 95% CI 11.5–14.4), but all pediatric age groups were more likely to elicit consultation than adults. Poisonings of unknown intent were the least likely to have WPC consultation (aOR 0.12, 95% CI 0.12–0.13).

Limitations

This study was a retrospective review of hospital administration data, which limits inferences that can be made regarding the causality of the associations identified herein. Stratified analysis was limited to age, intent, and gender, and so we are unable to identify any potential outcome disparities that could have been associated with unmeasured variables such as race/ethnicity and class of medication/agent implicated. Notably, there could have been baseline differences in acuity of the patients not accounted for by the variables used in the matching methodology. Another limitation was the fact that length of stay was reported in days, not hours, meaning that clinically significant differences in the length of shorter stays (e.g., 6–48 h), which are particularly common in the pediatric demographic, might not have been detected. Other limitations include the fact that the use of data from one state and one poison center may limit generalizability due to regional differences in demographics and practice patterns. While we were able to collect a large quantity of data, the majority were incomplete and therefore were not able to be included in the propensity matching analysis. Patient intent was determined from ICD-9 and ICD-10 codes, and therefore could be vulnerable to inaccuracy if these underlying data were incorrectly recorded.

Discussion

Previous studies, including one utilizing a similar methodology, have shown a decreased hospital length of stay associated with PCC consultation [6,7]. Our study shows that during an 8-year period, poison center consultation was associated with a 16% decrease in hospital length of stay after adjusting for baseline characteristics, which amounts to nearly a half-day decrease of hospitalization length in absolute terms. Decreased length of stay was observed in all age groups and intentionality classes. Compared to prior studies, this study's strengths include the use of more recent data. In addition, our study collected data over an 8-year period (versus one), and correspondingly has a larger sample size. Taken together, these studies demonstrate that the association between PCC consultation and decreased hospital length of stay is a durable, measurable correlation that has persisted over decades and been confirmed in different regions of the country.

Our study also showed that in patients aged 0–6 years, there was a greater reduction in length of stay than in the overall cohort (1.18 days versus 11.2 h). While average hospitalization charges were higher in the “WPC consulted” group overall, they were significantly lower (by \$6695) in the 0–6-year-old age group. Pediatric poisonings represent a substantial category of hospital admissions, averaging 9500 admissions yearly for medication ingestions alone in children aged 0–6 years [11], so the potential financial benefits of poison center consultation in pediatric admissions in this age group is significant.

In older children, WPC consultation was associated with decreased length of stay in all intentionality classes, but

Table 4. Regression analysis of factors associated with likelihood of poison center consultation.

Variable	Rate of WPC consultation	Odds ratio (95% CI)	Adjusted odds ratio (95% CI)
Age: 0–6 years	39% (694/1775)	8.32 (7.55–9.18)	12.9 (11.5–14.4)
Age: 7–12 years	16% (153/945)	2.50 (2.10–2.98)	3.71 (3.02–4.56)
Age: 13–18 years	42% (2022/4787)	9.48 (8.91–10.08)	4.17 (3.89–4.48)
Age: >18 years	7% (8575/119,717)	ref	ref
Intent: Accidental or Assault	14% (2389/17,114)	ref	ref
Intent: Intentional	31% (7613/24,592)	2.78 (2.63–2.94)	3.01 (2.85–3.18)
Intent: Unknown	1% (996/82,565)	0.11 (0.09–0.12)	0.12 (0.12–0.13)
Gender: Male	6% (4366/65,556)	ref	Ref
Gender: Female	11% (7078/62,668)	1.82 (1.75–1.89)	1.11 (1.06–1.16)

decreased charges only in cases of unintentional exposure (rather than self-inflicted or undetermined intent). Whereas the unintentional class dominated the 0–6 year-old age group (945/963, 98% of cases), in the older pediatric age groups self-inflicted poisoning was most common (141/242, 58% in 7–12 year-olds; 3769/4483 84% in 13–18 year-olds). In aggregate, these findings suggest that PCC consultation may be of particular benefit to reducing costs in pediatric patients with unintentional poison exposures specifically, and that the large charge decrease that was observed in the 0–6 year-old age group may have been driven at least in part by differences in the intentionality composition of poisonings between age groups.

Contrary to a prior study [7], our study found that after stratified matching, PCC consultation was associated with higher hospital charges overall. This effect was small, on the order of a 5.4% charge increase in relative terms and \$600 in absolute terms. It should be emphasized that hospitalization charges, the cost of providing care, and the value of the care provided are not the same. The correlation between these items is disrupted by myriad factors at play in the generation of the chargemaster – the comprehensive listing of billable items produced by every US hospital. Specifically, constraints in the form CMS reimbursement policy as well as the negotiating practices of third-party insurers have created an environment where hospitals attempting to optimize revenue do so by increasing charges on goods and services for which they have the greatest flexibility to set rates, rather than those which are the costliest to provide [12]. In addition, patients can and do appeal and renegotiate hospital charges. Given this, it is unsurprising that in our study the shorter length of stay in the “WPC Consulted” group was not correlated with a decrease in charges.

In addition, there are several potential causal and non-causal factors which could have contributed to higher charges in the “WPC Consulted” group. First, it is possible and perhaps intuitive that hospital staff are more likely to initiate PCC consultation on higher acuity, more critical patients. While stratified matching was performed to adjust for some differences in baseline characteristics, only age and intent (and in the sensitivity analysis, gender) variables were used, and it is plausible that our propensity matching did not fully account for an innate acuity difference between the “WPC consulted” group and “WPC not consulted” group. As higher acuity cases are more likely to generate higher hospital charges, at least some component of the correlation between WPC consultation and higher charges is potentially non-causal in nature. In terms of potential causal factors,

poison center consultation often includes recommendations to order additional testing, such as acetaminophen or salicylate concentrations, toxic alcohol screens, electrocardiograms, and so forth. The charges for such testing are similar to the magnitude of charge increase in the “WPC consulted” group and is a viable explanation for the potential difference observed. Notably, our study examined primary outcomes of charges and length of stay. In terms of the finding of increased charges, it did not assess for the potential benefits incurred from the services charged for – such as the possibility that additional testing led to the diagnosis of comorbid conditions, or that recommended therapies improved patient outcomes. As such, there could have been added patient-centric value from PCC consultation which was both clinically meaningful and not captured by the data obtained.

The decrease in cost from reduction in hospital length of stay is clear, even if not associated with a reduction in charges. Hospital length of stay is a proxy for the consumption of hospital resources [13]. Vis-à-vis the fact that charges were increased in the “WPC Consulted” group despite a shorter length of stay, prior analysis has shown that while there are hospital efficiency benefits to decreasing hospital length of stay by maximizing the workload of a given patient care space, the patient-level charge reductions from length of stay improvement are minimal [14]. Finally, our data only captures the association between charge and PCC consultation on hospitalized patients. Potential cost and charge savings from ED consultation of the PCC are not captured – such as from cases where observation admissions are prevented for patient encounters where an ED physician would otherwise not be comfortable with home discharge or direct psychiatric disposition.

Our data show several factors that were associated with a higher likelihood that our PCC would be consulted regarding a case. Firstly, intentional overdoses were more likely to elicit consultation. This finding mirrors national registry data of hospitalized poisoned patients wherein intentional pharmaceutical and intentional non-pharmaceutical exposures were the most frequently reported exposure categories [15]. We also observed more frequent PCC consultation on cases involving female patients even though men are more likely to take a lethal medication overdose [16–18]. The difference in consultation rates between genders could have been secondary to gender bias on the part of medical caregivers, or due to differences in prescribing patterns between the genders. Men and women are prescribed different classes of medications at different frequencies, be they cardiovascular medications, opioid analgesics, or psychotropics [19–21]. In

addition, women are more likely to be prescribed unique medications than men [22].

Pediatric overdoses most strongly predicted PCC consultation, with the youngest age group having the highest odds ratio for likelihood of PCC consultation. Several factors could have contributed to this observed effect. These could include lesser Emergency Physician comfort in caring for pediatric patients without assistance, as compared to adults – a phenomenon which has been observed in survey data of physicians' attitudes regarding the care of pediatric trauma and cardiac arrest patients [23]. Other plausible explanations include a potentially higher tendency of Pediatric Emergency Medicine-trained physicians or other staff at pediatric-specialized facilities to seek poison center consultation as per training, facility policy, or specialty-specific cultural factors. Also, the lower body mass of children resulting in a higher dose-per-volume for a given amount of medication or other agent ingested, the innate proclivity of children to engage in exploratory ingestions and incur exposure to alternative agents as compared to adults, and/or the fact that parents of children may be more likely to call the poison center and initiate care (with the poison center following up to continue contact through hospital arrival and discharge) versus bystanders of adult ingestion could contribute to this effect. Further investigation of our observations could take the form of practitioner surveys or other prospective instruments to identify attitudes about which poisoning cases are felt to warrant expert assistance; or the use of more inclusive datasets with a greater ability to account for the effects of confounding variables on the measurement of these disparities.

Conclusion

In an evolving healthcare landscape, regional poison center consultations remain available 24/7/365, and are still associated with shorter hospital length of stay—particularly in pediatric patients, but in every other age group as well. In pediatric patients, consultation was also associated with a large decrease (\$6695) in mean hospital charges, while higher charges were observed in adult cases with PCC consultation. Further research on this topic should examine which patient specific factors such as demographics and type of exposure benefit most from poison center consultation.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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