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ORIGINAL ARTICLE

Resource Utilization in Emergency Department Patients with Known or Suspected Poisoning

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Abstract
Introduction Previous work has shown poisoning-related emergency department (ED) visits are increasing, and these visits are resource-intensive. Little is known, however, about how resource utilization for patients with known or suspected poisoning differs from that of general ED patients.
Methods We reviewed 4 years of operational data at a single ED. We identified visits due to known or suspected poisoning (index cases), and paired them with time-matched controls. In the primary analysis, we compared the groups with respect to a broad array of resource utilization characteristics. In a secondary analysis, we performed the same comparison after excluding patients ultimately transferred to a psychiatric facility.
Results There were 405 index cases and 802 controls in the primary analysis, and 374 index cases and 741 controls in the secondary analysis. In the primary/secondary analyses, patients with known or suspected poisoning had longer ED lengths of stay in minutes (370 vs. 232/295 vs. 234), higher rates of laboratory results per patient (40.4 vs. 26.8/39.6 vs. 26.8), greater administration of intravenous medications and fluids per patient (2.0 vs. 1.6/2.1 vs. 1.6), higher rates of transfer to a psychiatric facility (7.7 vs. 0.2%/not applicable), and higher rates of both admission (40.2 vs. 32.8/43.6 vs. 33.1%) and admission to an advanced care bed (21.5 vs. 7.6/23.3 vs. 7.8%). Patients with known or suspected poisoning had lower rates of imaging per patient, for both plain radiographs (0.4 vs. 0.5/0.4 vs. 0.5) and advanced imaging studies (0.3 vs. 0.5/0.4 vs. 0.5).
Conclusions ED patients with known or suspected poisoning are more resource intensive than general ED patients. These results may have implications for both resource allocation (particularly for departments that might see a high volume of such patients) and ED operations management.

Keywords Poisoning · Resource utilization · Emergency department

Introduction

Emergency care in the USA comes with a significant economic toll. One estimate based on 2008 data suggests these costs are on the order of 2 to 5–6% of overall health care spending, with another placing this estimate as high as 10% [1, 2]. This would equate to up to $240 billion in 2008 spent on emergency care alone.

Poisoning as a condition also exacts a large economic toll. Although poisoning accounts for a relatively small number of ED visits (on the order of 1% in the USA [3]), poisoning may generate significant hospital charges, including an estimated $7.9 billion in 2010 in Illinois [4, 5]. One study suggested that the direct cost of poisoning just from opioids in the USA in 2009 was approximately $2.2 billion, with a total cost of $20.4 billion [6].

Resource utilization, particularly in the ED, is an important part of the costs associated with these patients. Previous work has demonstrated that some groups have greater ED resource utilization profiles than general

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patients; for example, older patients have longer ED lengths of stay, young adult trauma patients intoxicated with ethanol have higher rates of computerized tomography (CT) utilization, and patients with congestive heart failure have very high rates of hospitalization [7–9].

Previous work on a national level has shown that in several key areas—medications administered or prescribed, use of CT, ED length of stay, and admission rate—resource utilization for poisoned patients has increased over time [3]. What is less clear, however, is the degree (if any) to which such patients differ from general ED patients. If poisoned patients have higher resource utilization profiles, this might be evidence not only that poisoned patients are more acutely ill but that centers that treat large numbers of such patients may need more resources than might be predicted by overall patient volumes alone. Furthermore, such a finding may have implications for ED management.

We sought to determine the extent to which resource utilization in patients with known or suspected poisoning differed from that of time-matched controls.

Materials and Methods

Study Design and Setting

This is a retrospective analysis of routinely gathered operational data. The study was part of a quality improvement project, and as such was identified as exempt from our institutional review board process with a waiver of the requirement for informed consent.

The Mayo Clinic Arizona Emergency Department is part of tertiary-care teaching hospital in Phoenix, Arizona. It is located in a suburban setting and staffed 24 hours per day with board-certified emergency physicians. During the study period, the ED saw an average of approximately 30,000 patients per year. There is no emergency medicine training program, but residents from multiple services rotate through the ED as providers, assisting in the evaluation of approximately 5% of patients. There is no "Fast Track." All patients undergo the same process of direct rooming for ambulance arrivals or triage followed by rooming (based on bed availability and acuity) for ambulatory patients.

With respect to patients with known or suspected poisoning or suicidal ideation, there are no mandatory laboratory panels, disposition policies (such as admission to the intensive care unit [ICU] for any poisoning or for administration of N-acetylcysteine), or protocols that mandate periods of ED observation. All patients with suicidal ideation at our facility are watched by 1:1 observers, but this has little or no effect on patient flow or disposition.

Selection of Participants

We reviewed 4 years of visit-level operational data (January 1, 2013 to December 31, 2016). Data were extracted from the electronic medical record (Cerner; Kansas City, MO) into a custom Microsoft Excel® spreadsheet.

We derived a list of poisoning-related terms (Table 1) based on our facility's experience, and used these terms to identify poisoned patients (index cases). We used the text filter function in Microsoft Excel to search four discrete data fields: ED chief complaint, ED discharge diagnosis, ED provider admission diagnosis, and admitting service admission diagnosis. Search terms retrieved all words containing that term, for example, "tox" retrieved not only "tox" but "toxic," "intoxication," "toxicity," etc. We searched ED chief complaint for all patients, and remaining fields when present. In addition, we searched the ED discharge diagnosis for the terms {T36, T37, T38,…, T50} to identify any patients with these poisoning-related or toxicity-related ICD-10 codes that were not identified by the keyword search (we did not include visits that were coded simply as adverse effects). Of note, our historical discharge diagnoses were harmonized with ICD-10 terminology, meaning that ICD-10 codes would be used in our dataset even during the time when ICD-9 was in use.

A poisoning-related complaint or condition in any of these fields qualified the patient as an index case. We excluded patients in whom the exposure produced an allergic reaction, as well as known or suspected isolated ethanol intoxication, withdrawal syndromes, and insect or spider bites, stings, or envenomations.

Controls were chosen based on time of arrival of the index cases. We matched each index case, when possible, with the visit that registered immediately prior to and immediately after the index case. In the event that there were zero or one control patients who registered between patients with known or suspected poisoning, as many controls as possible were used rather than omitting the index case.

In a secondary analysis, we excluded all visits and matched controls that were transferred to a psychiatric facility. The goal

Table 1 Search terms used to identify poisoned patients

Overdose	Marijuana	Amphetamine
Poison	Cocaine	Ambien
Drug	Tylenol	Opiate
Substance	Acetaminophen	Opioid
Ingestion	Oxy	Narcotic
Overmed	Aspirin	Serotonin
OD	Benzo	Lithium
Soma	Heroin	Tox
Meth		

of the secondary analysis was to reduce confounding due to behavioral health issues.

We assessed baseline characteristics of index cases and controls with respect to age, gender, and emergency severity index (ESI) score; ESI score was assigned in typical fashion by the triage nurse, with 1 representing the highest and 5 the lowest acuity. Age was recorded in integral years at the time of registration. Gender was assigned based on patient declaration.

Outcomes of interest were ED length of stay (LOS); degree of laboratory testing, intravenous medication and fluid administration, and plain radiograph and advanced imaging study (ultrasound, computerized tomography, and magnetic resonance imaging) utilization; rate of transfer to a psychiatric facility; rate of admission to the hospital; and rate of admission to any advanced care bed (ICU or intermediate unit).

We defined ED LOS as the time from registration to leaving the department. We assessed degree of laboratory testing through the number of laboratory results; at our facility, one order may be associated with multiple results. For example, the single-order "electrolytes" at our institution will generate four results (sodium, potassium, chloride, and bicarbonate). Plain radiographs and advanced imaging studies represent the total number of studies ordered. Intravenous medications and fluids represent the total number of items ordered for administration in the ED. Rate of transfer to a psychiatric facility reflects the percentage of patients who were physically transferred, not the percentage evaluated for psychiatric concerns. Admission rate represents the percentage of patients admitted to our hospital or transferred to another acute care medical hospital for admission. Admission rates to an advanced care bed (intensive care unit or intermediate care) represent the percentage of total patients admitted to our facility who were admitted to these high-acuity units.

Statistical Analysis

Descriptive summaries consist of mean and standard deviation for quantitative variables, and percentages for categorical data. The *p* values resulting from the comparison of cases vs. controls were based on results from conducting a univariate conditional logistic in order to account for the clustering due to matching cases vs. controls, and testing if the resulting odds ratio is equal to 1 vs. not. The conditional logistic regression model included the grouping factor (cases vs. control) as the binary outcome and each risk factor as the covariate. Statistical analyses were performed using the statistical software package SAS Studio version 3.4 (SAS Institute, Cary, NC). Significance was set at 0.05.

Results

There were 118,938 total ED visits in the 4-year period. Four hundred five (0.34%) met the criteria of known or suspected poisoning. These 405 cases were paired with 802 controls. In the secondary analysis, there were 374 patients and 741 controls.

Patient Characteristics

In both the primary and secondary analyses, poisoned patients were younger and presented with higher acuity (lower ESI scores) than general ED patients. In both analyses, there were no differences between the groups with respect to gender. Data for these findings and differences are presented in Table 2.

Patient Outcomes

In both the primary and secondary analyses, poisoned patients were more resource intensive than general ED patients with respect to ED resource utilization (ED length of stay, degree of laboratory testing, and number of intravenous medications and fluids), hospital resource utilization (need for admission and admission to any advanced care bed), and need for transfer to a psychiatric facility (in the primary analysis only). In both analyses, poisoned patients were less resource intensive than general ED patients with respect to number of plain radiographs and advanced imaging studies ordered. Data for these findings and differences are presented in Table 3.

Discussion

Resource utilization in medicine has become increasingly more scrutinized. The discussion of resource utilization in medical toxicology may involve global costs [4, 5], the impact of consultations with poison control centers (which are associated with a decrease in hospital admissions, inpatient length of stay, ED visits, and ED costs [10–15]), or the impact of an inpatient toxicology service (which is associated with a decreased inpatient length of stay [16]). Another aspect of resource utilization in medical toxicology which has not been extensively explored is the degree to which patients with known or suspected poisoning do (or do not) differ from general ED patients.

We were not surprised by our findings that these patients were more acutely ill, as measured by ESI score and admission to advanced care units. We note, however, that ESI score and admission to advanced care units may be imperfect surrogates of illness severity. Facilities that do not see a large number of poisoned patients may be somewhat intimated by them, and "err on the side of caution" by assigning such

Table 2 Patient characteristics

A. All patients				
Characteristic	Index cases (*n* = 405)	Control cases (*n* = 802)	Difference	*p* value[a]
Age	*45.1 (21.8)*	*57.8 (21.0)*	*−12.7*	*<0.001*
Gender (female)	58.5%	54.2%	+4.3%	0.157
ESI score				*<0.001*
1	6.0%	1.1%	+4.9%	
2	51.9%	13.5%	+38.4%	
3	37.2%	75.1%	−37.9%	
4	4.7%	10.1%	−5.4%	
5	0.2%	0.1%	+0.1%	
B. Patients not transferred to a psychiatric facility				
Characteristic	Index cases (*n* = 374)	Control cases (*n* = 741)	Difference	*p* value
Age	*45.8 (21.9)*	*58.0 (21.0)*	*−12.2*	*<0.001*
Gender (female)	54.7%	57.2%	+2.5%	0.422
ESI score				*<0.001*
1	6.2%	0.9%	+5.3%	
2	48.9%	14.1%	+34.8%	
3	39.5%	74.7%	−35.2%	
4	5.1%	10.1%	−5.0%	
5	0.3%	0.1%	+0.2%	

Age in years as mean (standard deviation) and gender and ESI as percentage. Mathematical relationships may appear imperfect due to rounding. Statistically significant differences are presented in italic

[a] Conditional logistic regression

patients higher ESI scores or having a lower threshold to admit them to advanced care beds.

While we were not surprised by the increased resource utilization (except for imaging) among patients with known or suspected poisoning, we were surprised by the magnitude of several of these findings. In the primary analysis, patients with known or suspected poisoning had a mean ED LOS that was more than 2 h longer, an admission rate to an advanced care bed that was 3 times as high, and a rate of transfer to a psychiatric facility that was 40 times as high as time-matched controls. Findings within the secondary analysis were similar, with the exception that LOS, while higher, was somewhat less so and the rate of transfer to a psychiatric facility was (by definition) not assessed. We suspect that the difference in ED LOS between the primary and secondary analyses was due to long waits for transfer often seen in patients who require treatment at an inpatient psychiatric facility.

Our findings build upon, and provide additional context to, previous work regarding resource utilization for poisoned patients. An analysis of poisoning-related ED visits from 2003 to 2011 found increases over that time period in ED length of stay (from 254 to 344 min), admission rate (from 15.5 to 21.8%), and rate of CT use (from 5.2 to 13.7%) [3]. While important, these findings were of general trends over time rather than a comparison of poisoned patients with general ED patients. We hope that our findings—which compare patients with known or suspected poisoning vs. controls—will add to overall knowledge in this area.

The differences we found impact multiple different areas of ED operations. The higher acuity (as measured by ESI score) and need for more intravenous medications and fluids have a direct impact on nursing. The longer ED LOS strains the ED infrastructure. The higher rates of admission and admission to any advanced care bed (ICU or intermediate care) may all strain hospital infrastructure, which can in turn have upstream consequences on ED patient flow [17]. The requirement for more intensive laboratory evaluation puts an added stress on laboratory services. The rate of transfer to a psychiatric facility (noted in the primary analysis) requires administrative work and coordination, and in many facilities (including ours), a long wait for transfer to a psychiatric facility is a cause of extended ED LOS.

On a practical level, the overall strain placed on our system by patients with known or suspected poisoning was likely very low, as such patients accounted for only 0.34% of all visits at our facility. If generalizable, however, these results may have significant implications for resource allocation in facilities that serve high volumes of poisoned patients. In any system, if resource allocation decisions are made simply on the basis of patient volume, facilities that care for a higher

Table 3 Outcomes

A. All patients				
Outcome	Index cases (n = 405)	Control cases (n = 802)	Difference	p value[a]
Emergency department				
Length of stay (min)	370 (538)	232 (202)	+138	<0.001
Plain radiographs/patient	0.4 (0.6)	0.5 (0.8)	−0.1	<0.001
Advanced imaging/patient	0.3 (0.6)	0.5 (0.7)	−0.2	<0.001
Laboratory results/patient	40.4 (24.6)	26.8 (21.0)	+13.6	<0.001
V medications and fluids/patient	2.0 (2.4)	1.6 (2.1)	+0.4	0.001
Transfer rate to psychiatric facility	7.7%	0.2%	+7.5%	<0.001
Hospital				
Admission rate	40.2%	32.8%	+7.4%	0.011
Admission rate/advanced care	21.5%	7.6%	+13.9%	<0.001
B. Patients not transferred to a psychiatric facility				
Outcome	Index cases (n = 374)	Control cases (n = 741)	Difference	p value[a]
Emergency department				
Length of stay (min)	295 (406)	234 (210)	+61	0.001
Plain radiographs/patient	0.4 (0.6)	0.5 (0.7)	−0.1	0.013
Advanced imaging/patient	0.3 (0.6)	0.5 (0.7)	−0.2	<0.001
Laboratory results/patient	39.6 (25.1)	26.8 (21.1)	+12.8	<0.001
IV medications and fluids/patient	2.1 (2.4)	1.6 (2.1)	+0.5	<0.001
Hospital				
Admission rate	43.6%	33.1%	+10.5%	0.001
Admission rate/advanced care	23.3%	7.8%	+15.5%	<0.001

Values are expressed as mean (standard deviation) or percentages. All differences are statistically significant

[a] Conditional logistic regression

number of poisoned patients may find themselves significantly shortchanged.

The finding that patients with known or suspected poisoning are more resource intensive also has potential implications for ED operations management. Complexity-augmented triage (in which nurses provide an up-front estimate of complexity in addition to a standard ESI score [18]) and complexity-based streaming (in which complex patients are placed into a separate processing stream [19]) are both proposed as mechanisms to improve ED throughput. These techniques are most effective when it is relatively easy to identify complex patients, and patients with known or suspected poisoning may represent one such group.

One limitation to this work is that we lack information regarding involvement of a poison control center. We believe that the differences in resource utilization we found were most likely due to differences in patient acuity and complexity; however, it is possible that our results reflect some degree of overutilization of resources due to an underutilization of poison center consultation. Early involvement of toxicologists and poison information specialists might have allowed for more rapid discharge, early triage to psychiatry, or decreased resource utilization. Further research might help to answer this question.

Another limitation arises from our choice of matching. We used a small number of time-matched controls, rather than the entire ED population, when comparing poisoned patients to general ED patients. We chose this approach intentionally to control for the operating environment of each visit, as the time-dependent state of the ED can have a significant effect on many of the variables (particularly LOS) that we measured. Our methodology, however, does not allow us to determine if patients with known or suspected poisoning utilize resources at a higher rate than other patients after controlling for demographic factors such as age and sex, or other characteristics such as ESI score. As our goal was to determine the extent to which a condition (known or suspected poisoning) is associated with differential resource utilization, and not the degree to which this condition affects resource utilization after controlling for patient characteristics, we believe that our matching was appropriate.

Our low rate of ED patients with known or suspected poisoning (0.34%) deserves discussion, as recent data suggest that in the USA this rate is approximately 1% [3]. There are several possible explanations for this. We used a technology-aided manual search of ED data that may not have captured every case; for example, a patient whose chief complaint and admission diagnosis were both altered mental status would not have been identified as a poisoned patient even if the etiology of their alteration in mental status was ultimately determined to be a drug overdose. We also intentionally omitted several categories of visits (most notably ethanol poisoning) that are explicitly included in other definitions. Only 3% of our visits are for pediatric patients (defined as <18 years old), removing a group in which poisoning is relatively common. Finally, our adult ED patient population reflects (in large part) the patient mix of our institution, which is older (median age of all patients of 61 years) and enriched for conditions such as organ transplantation and advanced cancer. It is possible that the incidence of poisoning is lower in such groups than in the general adult population.

Our list of search terms was chosen based on our facility experience. We chose this method as we focus on the ED implications for such patients. Including hospital discharge diagnoses may have identified more poisoned patients, but it is likely that some of these patients would not fit into the category of known or suspected poisoning in the ED.

Importantly, our low rate of poisoning, dearth of pediatric cases, somewhat atypical nature of our adult population, and use of site-specific search terms all potentially limit the generalizability of our findings to other facilities.

We included specific ICD-10 codes (T36–T50), but excluded some cases based on modifiers (i.e., “adverse effect”). We note that alternative modifiers for these diagnoses (such as “poisoning”) are available, and we did not exclude such patients. Our decision to exclude patients modified as adverse effect reflected our experience that many such cases represent mild symptoms that are temporally associated with therapeutic drug ingestion that may or may not be associated with the drug in question. However, our methodology might also have removed some patients who could be considered index cases, particularly if the arbiters of the adverse effect vs. poisoning/toxicity decision (who may have been financial personnel rather than practicing clinicians) were not well versed in the differences. We chose this approach to preserve specificity in the index group with respect to known or suspected poisoning, but acknowledge the limitations in doing so.

Our decisions regarding inclusion may have skewed our results towards intentional ingestions and suicidal patients. To the extent that such behavioral health patients are different from other patients, this represents a potential source of confounding. In order to reduce this effect, we performed a secondary analysis that excluded all patients transferred to a psychiatric facility. We note, however, that this did not completely eliminate a behavioral health bias; patients who underwent psychiatric screening but were not ultimately transferred to a psychiatric facility would be included in the secondary analysis. We do not capture this information electronically, and we lacked the resources to perform a manual chart review of a dataset of this size. This has important ramifications with respect to data interpretation, particularly as it pertains to ED LOS.

Our decision to eliminate certain groups warrants further discussion. We eliminated patients with ethanol intoxication for two reasons. First, most emergency physicians have extensive experience in treating patients with ethanol intoxication, and toxicology resources (such as poison centers) are rarely mobilized to diagnose or treat this condition. Second, the number of ethanol intoxication patients at our facility is greater than the sum of all other known or suspected poisonings, which we believe would have obscured any results we found in non-ethanol cases. We also eliminated envenomations, although we evaluate many patients with *Centuroides*-related complaints. We believed that including such patients would further limit the generalizability of our findings, which is already a concern.

In conclusion, in a single-facility study, we found that patients with known or suspected poisoning were younger, more acutely ill, and (with the exception of imaging) utilized significantly more resources than general ED patients. Additional research is needed to explain these differences in order to improve emergency department operations management.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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