Effect of a Medical Toxicology Admitting Service on Length of Stay, Cost, and Mortality Among Inpatients Discharged with Poisoning-Related Diagnoses

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Abstract There are no published studies that have compared quality outcomes of hospitalized poisoned patients primarily under the care of physician medical toxicologists to patients treated by non-toxicologists. We hypothesized that inpatients primarily cared for by medical toxicologists would exhibit shorter lengths of stay (LOS), lower costs, and decreased mortality. Patients discharged in 2010 and 2011 from seven hospitals within the same health care system and greater metropolitan area with Medicare severity diagnosis-related groups for “poisoning and toxic effects of drugs” with and without major comorbidities or complications (917 & 918, respectively) were identified from a Premier® database. The database contained severity-weighted comparisons between expected and observed outcomes for each patient. Outcome

parameters were differences between expected and observed LOS, cost, and percent mortality. These were then compared among groups of patients primarily admitted and cared for by (1) medical toxicologists at one hospital (Banner Good Samaritan Medical Center, BGS), (2) non-toxicologists at BGS, and (3) non-toxicologists at six other hospitals. Records of 3,581 patients contained complete data for assessment of at least one outcome measure. Patients cared for by medical toxicologists experienced favorable differences in LOS, costs, and mortality compared with other patient groups ($p < 0.001$). If patients cared for by non-toxicologists had experienced similar differences in observed over expected values for LOS, cost, and mortality as those cared for by medical toxicologists, there would have been a median savings of 1,483 hospital days, \$4.269 million, and a significant decrease in mortality during the 2-year study period. Differences between observed and expected LOS, cost, and mortality in patients primarily cared for by medical toxicologists were significantly better than in patients cared for by non-toxicologists, regardless of facility. These data suggest that significant reductions in patient hospital days, costs, and mortality are possible when medical toxicologists directly care for hospitalized patients.

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Introduction

In 2012, US regional poison control centers (PCCs) received over 2.2 million calls related to human exposures and poisonings. Of these, 613,412 (26.9 %) patients were managed in a health care facility and 100,455 (4.4 %) were admitted to intensive care units [1]. In 2011, non-fatal poisoning-related inpatient hospitalization charges in Arizona totaled more than \$127 million for 13,822 hospital days of care, and 1,144

additional persons died from poisoning. In fact, poisoning became the leading cause of injury death in Arizona, exceeding deaths from motor vehicle accidents [2]. Efforts to lessen mortality, shorten hospital stays and decrease costs would be of benefit to society.

Physicians with subspecialty training in medical toxicology (hereafter, medical toxicologists) often participate in PCC operations that provide free telephone consultation to other health care providers [3, 4]. Prior studies have shown that PCC involvement in the management of poisoned patients results in health care savings [5–13]. It has also been demonstrated that patients managed with PCC telephone consultation utilize the emergency department (ED) less frequently and experience lower rates of hospital admission and shorter lengths of stay (LOS) when hospitalized [7, 14–17]. However, very limited data exist regarding consultative bedside management of poisoned patients by medical toxicologists, and no studies have reported major quality outcomes in patients admitted to a medical toxicology service where care was primarily delivered by medical toxicologists [18, 19].

At our academic medical center, medical toxicologists operate an inpatient admitting service that cares for over 1,100 patients annually. Our hospital is a member of Banner Health, a large multistate health care system that includes multiple facilities within the greater Phoenix, Arizona area (population approximately four million), that are connected via a shared electronic medical record. This connectivity provides enhanced sharing of medical information as well as unique quality assessment and research opportunities.

Based on existing evidence, we hypothesized that patients admitted for poisoning-related reasons that primarily received care from medical toxicologists would experience reduced LOS, hospital costs, and mortality when compared to similar hospitalized patients cared for by non-toxicologist physicians (non-toxicologists). To evaluate this hypothesis, we began a retrospective review of hospitalized patient data in late 2012 that encompassed 2 years (2010–2011) of patient discharges to determine what effects admission to a medical toxicology service following a poisoning-related injury had on LOS, hospital cost, and mortality.

Methods

This study was approved by Banner Health Institutional Review Board. Medical toxicologists from a single physician group admit and care primarily for toxicology patients at Banner Good Samaritan Medical Center (BGS), a 668-bed tertiary-care teaching hospital. All patients admitted to the medical toxicology service are evaluated and treated by board-eligible or board-certified medical toxicology attending faculty, frequently working closely with fellows undergoing toxicology subspecialty training. The great majority of these

patients are transferred from other facilities within Arizona and the Southwest and are directly admitted to an intensive care unit. Within the same hospital system in the greater Phoenix area, there were six other hospitals, each greater than 200 beds in size, to which non-toxicologists admitted and cared for similar patients during the period of this study. These six additional hospitals ranged in size from 214 to 639 beds and had specialists on staff such as intensivists, cardiologists, pulmonologists, and surgeons available to participate in management of critically ill and non-critically ill patients upon consultation by the admitting physician. Collectively, about 180,000 patients were discharged from BGS and the six additional hospitals annually. All hospitals shared a common electronic medical record, including access to standardized physician orders. Furthermore, all hospitals utilized the same reference laboratory, and comprehensive toxicology testing was performed for all hospitals at one toxicology laboratory located at BGS. A regional PCC based at BGS provided services to the greater Phoenix area and followed patients at all included hospitals.

Hospitals described in this study participated in a database maintained by Premier Inc.[®] (Charlotte, NC), into which demographic and clinical data for patients discharged from hospitals across the USA were entered. In 2012 (at the time of data acquisition), Premier's database contained information extracted from 860 US hospitals who contract with Premier for quality measures database management. The Premier database accounted for more than 25 % of all inpatient discharges, nationally, at the time of this study [20, 21]. This database contained risk-adjusted outcomes for length of stay (LOS; days), cost (dollars, standardized with cost-to-charge ratio), and mortality (percent), wherein each patient discharge was severity-adjusted independently and given its own *expected* outcome that was matched to the *observed* outcome. The risk methodology to calculate expected outcomes first used a step-wise linear probability regression model that included 16 patient characteristics, patient health status indicators, and socioeconomic factors in the risk adjustment (e.g., age, gender, principle diagnoses, relevant procedures, comorbidities). These independent variables, or patient contributions to risk, were used to create an expected value for each patient discharge based on the patient's own risk profile when examining similar patients in the database. That is, expected values for LOS, cost, and mortality were adjusted for severity of illness.

Previous internal quality assurance data indicated that BGS performed at or better than the mean of the top two quintiles of similar hospitals, nationally, in the care of toxicology patients. Therefore, expected values were further scaled using the Select Practice[™] methodology [22]. In this methodology, LOS, cost, and mortality were examined among patients discharged from more than 2,000 hospitals nationwide, and hospitals performing in the top 16 % in quality and efficiency in 60

disease strata were compared to all hospitals, overall, to calculate a scaling factor. For example, if the top 16 % performing hospitals reported a 20 % shorter LOS compared to all hospitals, the initially calculated severity-adjusted expected LOS was decreased by 20 % to create a more stringent expected outcome. Calculation of severity-weighted expected outcomes allowed for comparison of expected with observed outcomes among aggregated patient groups in our health care system.

From the Premier® database, we identified all patients ≥ 14 years of age discharged from BGS and the six additional aforementioned hospitals in years 2010 and 2011 with Medicare severity diagnosis-related group (DRG) discharge diagnoses codes for “poisoning and toxic effects of drugs” with and without major complications or comorbidities, 917 and 918, respectively. This 2-year period was chosen as representing the most recently available and complete data for hospitals in this study, comprising more than 3,000 patient discharges with DRGs of interest. For each patient, the database provided observed LOS, cost, and mortality as well as individual severity-adjusted expected values for these same parameters that had been scaled using Select Practice™ methodology. Data were abstracted electronically using the aforementioned search parameters by a single author (SG), who is a non-physician and non-toxicologist and was blinded to data analyses.

Patients from all seven hospitals were divided into three groups. Group 1 comprised patients admitted and cared for by medical toxicologists at BGS. Patients seen in consultation by medical toxicologists at BGS, but not directly admitted by them, were excluded since medical toxicologists were not primarily responsible for their admission, care, or discharge. Group 2 comprised patients admitted and cared for by non-toxicologists at the same facility (BGS). Finally, those patients admitted and treated by non-toxicologists at the six additional hospitals within the same system composed group 3.

Statistical Analyses

Outcome parameters for LOS, cost, and mortality were the differences between observed and expected values. That is, differences (observed–expected LOS, cost, and mortality) were calculated for each patient in each of the two DRG groups, and these differences were compared among the three groups of patients using Kruskal-Wallis tests, given non-normal distributions of outcomes. Comparing group 1 patients to patients both within BGS (group 2) and those at other facilities (group 3) helped control for hospital-specific variables such as nursing, laboratory services, and house staff, and helped to identify treatment effects related to the admitting service [23]. A two-tailed $p < 0.05$ was chosen to represent statistical significance, and all p values were nominal.

We also calculated potential lives saved per thousand patients, in which the number of expected deaths was the sum for all predicted mortality values for patients within a given group. The difference in the number of deaths (expected–observed) represented potential lives saved, and this value was standardized for 1,000 patients.

No formal power calculation was performed, given lack of published estimates of treatment effect, non-normally distributed outcomes, and variation in patient numbers in different patient groups.

Results

A total of 3,581 patients ≥ 14 years of age whose database record contained information allowing analysis for at least one outcome parameter were discharged from the seven hospitals during the 2-year study period with DRGs of interest: 1,354 patients with DRG 917 and 2,227 patients with DRG 918.

Length of Stay

Complete LOS data were available for 3,581 patients (Table 1). When comparing differences in DRG 917 patient groups among each other, group 1 patients experienced a significantly shorter LOS compared to expected values (0.3 days shorter) than groups 2 and 3 (0.5 and 0.4 days longer, respectively) [$p < 0.001$].

For DRG 918, patients in group 1, again, experienced a median 0.3 days shorter than expected LOS. Patients in groups 2 and 3 remained hospitalized 0.1 days shorter and 0.2 days longer than expected, respectively [$p < 0.001$].

Cost

Complete cost data were available for 3,569 patients (Table 2). Group 1 patients with DRG 917, cared for by medical toxicologists, generated significantly decreased observed versus expected costs (median difference \$1,798) compared to increased median cost differences of \$703 and \$636 in groups 2 and 3, respectively ($p < 0.001$).

Similar findings were observed for patient groups with DRG 918, where differences between expected and observed costs per patient were favorable by a median of \$1,016 for those cared for by medical toxicologists, compared with a favorable median difference of \$358 for group 2 and an unfavorable median difference of \$204 for group 3 ($p < 0.001$). For both DRGs, cost differences in group 2 patients were more similar to those in group 3 than in those in group 1.

Table 1 Length of stay (LOS) per patient in days. Differences in LOS represent median and IQR values for all observed minus expected values for individual patients in each group. Expected LOS values are severity-adjusted (see “Methods”)

Length of stay				
Patient group	No. of pts	Expected LOS per pt (days)	Observed LOS per pt (days)	Difference*LOS per pt (days)
DRG 917: Poisoning and toxic effects of drugs with MCC median [IQR]				
Group 1 (BGS toxicologists)	416	2.7 [2.0–3.6]	2.4 [1.6–3.7]	−0.3 [−1.3–0.9]
Group 2 (BGS non-toxicologists)	115	3.4 [2.4–4.7]	3.9 [2.6–6.7]	0.5 [−0.7–2.6]
Group 3 (non-BGS/non-toxicologists)	823	2.5 [1.9–3.5]	3.0 [2.0–5.0]	0.4 [−0.6–1.8]
Total	1,354			
DRG 918: Poisoning and toxic effects of drugs without MCC median [IQR]				
Group 1 (BGS toxicologists)	537	1.7 [1.5–2.2]	1.6 [1.0–2.2]	−0.3 [−0.9–0.3]
Group 2 (BGS non-toxicologists)	100	2.2 [1.8–2.9]	2.1 [1.6–3.8]	−0.1 [−0.8–1.2]
Group 3 (non-BGS/non-toxicologists)	1590	1.7 [1.4–2.2]	2.0 [1.3–3.1]	0.2 [−0.6–1.1]
Total	2,227			

Patients in group 1 were admitted and cared for by medical toxicologists at BGS. Patients in group 2 were cared for by non-toxicologists at BGS. Patients in group 3 were cared for by non-toxicologists at six additional hospitals within the same health care system.

* $p < 0.001$, comparing differences among groups, by Kruskal-Wallis test.

MCC major complications or comorbidities, *pt* patient, *IQR* interquartile range.

Mortality

Mortality data were available for 3,579 patients (Table 3). Mortality data in Table 3 are expressed as means with 95 % confidence intervals for better understanding, since the relatively low mortality rates resulted in observed *median*

mortalities of zero for all groups, despite significant differences in number of deaths.

When comparing differences among groups with DRG 917, group 1 patients experienced significantly lower than expected mortality than other groups ($p < 0.001$). In DRG 918 patients (without comorbidity or complications), no

Table 2 Cost per patient in dollars. Differences in cost represent median and IQR values for all observed minus expected values for individual patients in each group. Expected cost values are severity-adjusted (see “Methods”)

Cost				
Patient group	No. of pts	Expected cost per pt (dollars)	Observed cost per pt (dollars)	Difference* cost per pt (dollars)
DRG 917: Poisoning and toxic effects of drugs with MCC median [IQR]				
Group 1 (BGS toxicologists)	415	6,739 [4507–10151]	4,779 [3179–8118]	−1798 [−4723–727]
Group 2 (BGS non-toxicologists)	108	8,424 [5714–12142]	9,575 [6356–18049]	703 [−1658–4551]
Group 3 (non-BGS/non-toxicologists)	819	6,362 [4661–9465]	7,165 [4851–11187]	636 [−1297–2931]
Total	1,342			
DRG 918: Poisoning and toxic effects of drugs without MCC median [IQR]				
Group 1 (BGS toxicologists)	537	4,128 [3148–5319]	2,735 [1819–4454]	−1016 [−2440–353]
Group 2 (BGS non-toxicologists)	100	5,163 [4001–6584]	4,667 [3555–7037]	−358 [−1910–1246]
Group 3 (non-BGS/non-toxicologists)	1590	3,921 [3247–4987]	4,329 [3041–5909]	204 [−1140–1703]
Total	2,227			

Patients in group 1 were admitted and cared for by physician medical toxicologists at BGS. Patients in group 2 were cared for by non-toxicologists at BGS. Patients in group 3 were cared for by non-toxicologists at six additional hospitals within the same health care system.

* $p < 0.001$, comparing differences among groups, by Kruskal-Wallis test.

MCC major complications or comorbidities, *pt* patient, *IQR* interquartile range.

Table 3 Mortality. Patients in group 1 were admitted and cared for by physician medical toxicologists at BGS. Patients in group 2 were cared for by non-toxicologists at BGS. Patients in group 3 were cared for by non-toxicologists at six additional hospitals within the same health care

system. Mean values and 95 % confidence intervals are reported for ease of interpretation, although data are not normally distributed (see “Methods”)

Mortality				
Patient group	No. of pts	Expected % mortality	Observed % mortality	Difference* % mortality
DRG 917: Poisoning and toxic effects of drugs with MCC mean [95 % CI]				
Group 1 (BGS toxicologists)	415	7.17 [6.3–8.04]	1.69 [0.44–2.93]	–5.48 [–6.67 to –4.3]
Group 2 (BGS non-toxicologists)	115	7.33 [5.19–9.48]	9.57 [4.11–15]	2.23 [–2.36–6.83]
Group 3 (non-BGS non-toxicologists)	822	3.1 [2.74–3.46]	1.34 [0.55–2.13]	–1.77 [–2.53 to –1.01]
Total	1,352			
DRG 918: Poisoning and toxic effects of drugs without MCC mean [95 % CI]				
Group 1 (BGS toxicologists)	537	0.43 [0.35–0.5]	0	–0.43 [–0.5 to –0.35]
Group 2 (BGS non-toxicologists)	100	0.64 [0.34–0.95]	0	–0.64 [–0.95 to –0.34]
Group 3 (non-BGS non-toxicologists)	1590	0.4 [0.32–0.49]	0	–0.4 [–0.49 to –0.32]
Total	2,227			

* $p < 0.001$, comparing differences among groups, by Kruskal-Wallis test

MCC major complications or comorbidities, *pt* patient, *CI* confidence interval

deaths occurred in any patient group, which prevented meaningful statistical comparisons, though data are provided in Table 3 for completeness.

Table 4 summarizes potential lives saved, standardized to 1,000 patients, for DRG 917 in order to illustrate generalization of observations in Table 3 to larger populations. No data for lives saved are provided for DRG 918, given the low expected mortality rate and absence of deaths in these patients.

Discussion

Premier’s methodology and database, in which individualized severity-adjusted expected outcome parameters are calculated for each patient, are regularly used to evaluate mortality, costs, complications, morbidity, and resource utilization across a wide variety of patients and disease states [21, 24–28]. In this study, we focused on illnesses related to poisoning or toxic effects of drugs and demonstrated that inpatients primarily cared for by medical toxicologists, compared to patients primarily cared for by non-toxicologists and adjusted for predicted values, experienced significantly shorter hospital stays, generated lower costs, and suffered lower mortality. Our findings are in keeping with other studies that have examined outcomes where specialized care is delivered, for example, at trauma centers and in pediatric critical care units [29–32].

A major strength of our study was the comparison of patients cared for by medical toxicologists at BGS to similar patients under the care of non-toxicologists at the same

hospital as well as to patients cared for by non-toxicologists at other hospitals in the same locality and health care system. These comparison hospitals shared a common electronic medical record and toxicology laboratory services for comprehensive testing, and were served by the same regional poison center. The more favorable outcomes in group 1 patients, then, appeared to have depended more on primary treatment by medical toxicologists rather than on facility.

The reasons for more favorable outcomes in patients cared for by medical toxicologists probably include several factors, but were not examined in this study. Possibilities include more rapid and accurate recognition of toxidromes or recognition of clinical presentations that were incompatible with available histories, better anticipation of complications (e.g., delayed-onset seizures or cardiovascular collapse), withholding of unneeded diagnostic studies because of confidence in diagnoses, and more appropriate use of pharmaceutical agents that may be unfamiliar to other physicians (e.g., fomepizole, glucagon). Medical toxicologists may also have been more comfortable in discharging patients earlier, based on an understanding of toxicokinetics and natural courses of intoxications or adverse drug events.

When comparing LOS differences between groups, the favorable absolute difference between observed and expected LOS among medical toxicology patients, though statistically significant, may not be clinically significant on a *per-patient* basis (e.g., 0.3 days shorter than expected). However, when compared across groups and extrapolated to a hospital or health care system, many patient hospital days could potentially be saved by medical toxicologists’ care. Fractional days

Table 4 Potential lives saved per thousand patients for DRG 917. Patients in group 1 were cared for by physician medical toxicologists at BGS. Patients in group 2 were cared for by non-toxicologists at BGS.

Patients in group 3 were cared for by non-toxicologists at six additional hospitals within the same health care system.

Potential lives saved per thousand patients

DRG 917: Poisoning and toxic effects of drugs with MCC

Patient group	No. of pts	Expected no. of deaths	Observed no. of deaths	Lives saved (expected–observed)	Potential lives saved per 1000 patients
Group 1 (BGS toxicologists)	415	29.7	7	22.7	54.7
Group 2 (BGS non-toxicologists)	115	8.4	11	–2.6	–22.6
Group 3 (non-BGS non-toxicologists)	822	25.5	11	14.5	17.6
Total	1,352				

pt patient

of shorter hospital stay represent increased efficiency, are directly tied to cost reductions, and result in fewer hospital beds being required system wide.

In a previous study limited to patients with tricyclic antidepressant overdose, Clark et al. reported less gastrointestinal decontamination and ordering of fewer laboratory tests among 28 inpatients seen in consultation by medical toxicologists compared to 66 patients not seen in consultation [18]. In a descriptive Australian study, Lee and colleagues reported that 192 inpatients admitted to a combined general medicine and consultative medical toxicology service experienced a shorter length of stay than 113 patients not seen in consultation by medical toxicologists [19]. No previous studies have examined quality outcomes in patients admitted and primarily managed by medical toxicologists, and even studies describing consultations have not examined mortality.

Limitations to our study include that patients were identified in the Premier® database using discharge diagnostic codes rather than admission diagnoses, and there is the possibility of inaccurate DRG assignment after discharge. However, error in DRG assignment should have applied to all groups equally. The limited number of patients in group 2 compared to group 1 is in keeping with the fact that medical toxicologists primarily admit and care for most toxicology patients at BGS. The fact that group 2 patients were admitted to BGS and cared for by non-toxicologists rather than medical toxicologists suggests the possibility that these patients were different in ways that may not have been accounted for in severity adjustments, despite similar values for expected mortality (Table 3). Early identification of toxicology-related diagnoses may have led to toxicology service admission and favorably biased outcomes in group 1. Patients in group 2 may have included those in whom a toxicological diagnosis was initially unclear, perhaps increasing length of stay to allow for diagnostic evaluation or contributing to adverse outcomes. It is possible that some patients in group 2 may have been seen in consultation by medical toxicologists, but this would be expected to

lessen the difference between outcome parameters in group 1 and 2 patients. The relatively low numbers of patients in group 2 also somewhat limit comparisons of uncommon events, such as death, with other groups. The DRGs 917 and 918 used in our study did not include all inpatients admitted and cared for by medical toxicologists. However, we wanted to choose DRGs that encompassed many of our patients and for which there were adequate numbers of discharged patients at other facilities for use in comparisons. As noted in the methods, the absence of deaths in patients with DRG 918 prevents meaningful statistical comparisons between groups. Therefore, we can only report more favorable mortality outcomes among medical toxicology patients with major comorbidities or complications (DRG 917). Further study in a larger population in which deaths occur among DRG 918 patients will be required in order to make valid comparisons between groups. Medical toxicologists also care for children <14 years of age, but some facilities did not routinely admit and care for poisoned children. Given that management advice from poison center staff has previously been associated with more favorable outcomes, a limitation to our study might be that we did not adjust for poison center involvement with inpatient care in the three patient groups [6–15]. However, our PCC staff very uncommonly makes treatment recommendations for patients under the primary care of medical toxicologists at BGS (group 1). Therefore, any beneficial effect of PCC involvement, including telephone consultations provided by medical toxicologists, should have resulted in better outcomes for group 2 and group 3 patients. Finally, we suspect there was a selection bias for patients to be transferred and admitted directly to our service. The possibility of such bias is supported by a higher expected mortality in group 1 patients (7.1 %) discharged with DRG 917 compared to 3.1 % expected mortality among patients in group 3 (Table 3). This bias, however, is likely to have resulted in more severely ill patients in group 1, which would have favored results opposing our findings. Importantly, the purpose of using individual severity-adjusted

expected outcome parameters was to account for differences in severity of illness.

Previous internal quality assurance studies at our hospital indicated that LOS, cost, and mortality for poisoned patients were equal to or better than mean values in the highest two quintiles of top-performing hospitals in quality and efficiency across the nation. However, it was not the purpose of this study to contrast observed quality measures with expected values *within* groups for comparisons with hospitals nationwide. Rather, this study compared outcome parameters *between* groups to evaluate implications of inpatient care primarily delivered by medical toxicologists. However, inspection of Tables 1, 2, and 3 reveals that median LOS and costs and mean percent mortality were more favorable for group 1 patients cared for by medical toxicologists than expected values based on the top 16 % of performing hospitals in the nation. For example, group 1 patients with DRG 917 experienced a 71 % reduction in mean mortality below expected values (1.69 % observed versus 7.17 % expected). Similarly, there was a 29 % reduction in median cost and a 12 % reduction in median LOS per patient in group 1.

The design of this study helped identify that specialty-specific variables improved the clinical outcomes and cost of caring for poisoned patients more than facility-related variables. These data suggest that if all patients included in our study had experienced the same reductions from expected values in LOS, cost, and mortality as patients cared for by medical toxicologists, a median of about 1,483 patient hospital days and a median of approximately \$4.269 million (2010–2011 dollars) would have been saved over the 2-year study period, with significantly lower mortality.

Extending such projections to all hospitals in our health care system, in Arizona, or nationally, would be expected to produce proportionally larger effects. For example, when considering the difference between potential lives saved in group 1 and those cared for by non-toxicologists at outlying hospitals (group 3), there is theoretical potential to save about 37 additional lives per thousand patients discharged with DRG 917 within our health care system when care is primarily directed by a medical toxicologist. When comparing observed versus expected lives saved *within* hospitalized patients primarily under the care of medical toxicologists (group 1), more than 54 additional lives might be saved per 1,000 patients in top-performing hospitals, nationally (Table 4).

Conclusions

Patients discharged with DRGs for poisoning and toxic effects of drugs that were primarily cared for by medical toxicologists experienced more favorable differences in observed versus expected values for LOS, cost, and mortality when compared to inpatients cared for by non-toxicologists. These data

suggest that significant reductions in patient hospital days, costs, and mortality are possible when medical toxicologists care directly for hospitalized patients. Additional studies to evaluate differences among these patient groups, such as laboratory testing, procedures, and additional diagnoses, will be required to better understand the factors accounting for better outcomes in patients cared for by medical toxicologists.

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Conflict of interest All authors are employees of Banner Health.

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