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High call volume at poison control centers: identification and implications for communication

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Abstract

Context—High volume surges in health care are uncommon and unpredictable events. Their impact on health system performance and capacity is difficult to study.

Objectives—To identify time periods that exhibited very busy conditions at a poison control center and to determine whether cases and communication during high volume call periods are different from cases during low volume periods.

Methods—Call data from a US poison control center over twelve consecutive months was collected via a call logger and an electronic case database (Toxicall®). Variables evaluated for high call volume conditions were: (1) call duration; (2) number of cases; and (3) number of calls per staff member per 30 minute period. Statistical analyses identified peak periods as busier than 99% of all other 30 minute time periods and low volume periods as slower than 70% of all other 30 minute periods. Case and communication characteristics of high volume and low volume calls were compared using logistic regression.

Results—A total of 65,364 incoming calls occurred over 12 months. One hundred high call volume and 4885 low call volume 30 minute periods were identified. High volume periods were more common between 1500 and 2300 hours and during the winter months. Coded verbal communication data were evaluated for 42 high volume and 296 low volume calls. The mean (standard deviation) call length of these calls during high volume and low volume periods was 3 minutes 27 seconds (1 minute 46 seconds) and 3 minutes 57 seconds (2 minutes 11 seconds), respectively. Regression analyses revealed a trend for fewer overall verbal statements and fewer staff questions during peak periods, but no other significant differences for staff-caller communication behaviors were found.

Conclusion—Peak activity for poison center call volume can be identified by statistical modeling. Calls during high volume periods were similar to low volume calls. Communication

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the article.

Editorial supervision

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was more concise yet staff was able to maintain a good rapport with callers during busy call periods. This approach allows evaluation of poison exposure call characteristics and communication during high volume periods.

Keywords

Operations; Communication; High volume

Introduction

Poison control centers (PCCs) in the US are staffed by Specialists in Poison Information (SPIs), who are nurses, pharmacists, and other health care providers who dispense toxicology information by telephone to the general public and health care providers. For calls from the public, SPIs assess each situation by taking a thorough history and determine whether an exposure can be managed on-site or if an evaluation in a health care facility is necessary. Since the exchange of information is entirely via telephone, verbal communication skills are very important in establishing rapport with the lay caller and facilitating exchange of information and adherence to recommendations.

High call volumes may impact the ability for SPIs to respond effectively to incoming calls. Negative effects of high call volume may include dropped calls, prolonged wait times, increased errors, and poor communication. Poor health care provider communication is linked to lower patient adherence and other negative outcomes, and communication often suffers under stressful circumstances.^{1,2} Since US PCC encounters are dependent on the ability of SPIs to adequately communicate verbally with callers, it is especially necessary for them to maintain professionalism and competent care despite environmental pressures. However, there is little research to determine how busy conditions impact calls to poison centers, including how SPI communication may change.

The objectives of this study are to identify time periods that exhibit high call volume conditions in a PCC and to determine whether calls during these periods are different from low call volume periods in terms of case characteristics. A secondary objective is to examine a subset of cases for differences in communication behaviors between periods of high and low call volumes.

Methods

Data were collected from the Utah PCC over the 12-month period from 1 October 2007 through 30 September 2008, for a larger study of SPI-lay caller communication.³⁻⁵ All calls to the emergency hotline were routed to an automatic call distributor (ACD) that “answers” the call and a descriptive option menu is played for the caller. When the caller selects the “poisoning or overdose” option, the call is routed to ring on the phone of an available SPI. If all lines are busy, the call is routed to the call waiting queue until an SPI is available to take another call. If an SPI places a caller on “hold,” that call remains on the phone and the staff member can receive another call from the queue. Depending on the time of day, a minimum of one (midnight to 0700) to a maximum of three SPIs were available to answer incoming calls. A total of 14 SPIs answer the phones at the PCC. The SPIs answering incoming calls

were unaware of this research project for the duration of the study. This study was approved by the Investigational Review Board at the University of Utah.

Data collection tools

Call and case characteristics—Two tools were used to collect data for this study: the PCC electronic health record system (Toxicall®) and a call logger, Real Time Socket interface (RT-Socket; Avaya, Inc). SPIs record clinical data for each case using Toxicall® software (Computer Automation Systems, Inc) and over 70% of US PCCs use this system. It is a comprehensive 32-bit Windows application that was written specifically to capture and report poisoning exposure and information calls by US PCCs. The Toxicall® database can be queried to report the number of cases (not calls) documented for any given time period. The call logger is a combination of hardware and software that reported the status of the ACD and every phone line in the PCC at ten10-second intervals during the study period. An approximation of in-call duration (the amount of time an SPI is actively on the phone) was obtained by the call logger.

The following clinical characteristics were examined: age of patient, caller relationship to patient, number of substances ingested, intentional versus accidental, medical outcome, and route of exposure (i.e. ingestion). The following call variables were included: season of the year, day of week, and time of day.

Call volume—In order to operationalize periods of relatively high call volume, we evaluated three parameters that reflect SPI call activity: (1) amount of time SPIs spent on the phone (*in-call duration*), (2) number of cases managed (*Cases per SPI*), and (3) number of calls received (*Calls per SPI*). We created these three variables as a ratio (parameter/SPI/30-minute period). The time periods were based on the first and last 30 minutes of the hour, to yield 48 time periods per 24-hour day. These variables are described in detail below.

In-call duration is the average amount of time an individual SPI was actively on the phone during a 30-minute period. The call logger captured the status of each SPI every 10 seconds as either available for a call, currently on a call, unavailable to receive a call, or “in-ring” (phone is ringing, not answered yet). If no SPI was available, calls “waited” in the ACD queue until the next SPI was available. In-call duration includes both informational calls and exposure calls and excludes calls made directly to a particular workstation bypassing the ACD and any outgoing calls made by the SPI. The 10-second measurement interval permits an error that never exceeds 20 seconds per call. Assuming call beginnings and endings are independent and each uniformly distributed within the 10-second interval, the standard error of the measurement is 4 seconds per call. Call length was recorded for all communication-coded calls and used to calculate average call length for each type of call.

Cases per SPI is defined as the average number of new cases, both informational and exposures, documented per SPI in every 30-minute period. The number of SPIs available to document a case was calculated using the call logger, which reported an SPI present if the SPI was logged into the ACD. The number of cases per 30-minute period was obtained from the PCC Toxicall® database.

Calls per SPI was calculated based on the number of all in-coming calls per SPI in every 30-minute period identified by the call logger. It includes both informational calls and exposure calls and excludes calls made directly to a particular workstation bypassing the ACD and any outgoing calls made by the SPI.

Call communication—The communication data consists of a subset of a larger project.^{3–5} In the parent project, human exposure cases in which calls were made by a lay person (i.e. non-health care provider) were coded using Roter Interaction Analysis System (RIAS).⁶ Calls to be coded were drawn from a sample stratified by both high initial SPI severity and age. SPI's initial impression of severity was collected as previously described.⁵ The stratification was balanced with respect to age and unbalanced with respect to initial SPI severity. Our sample for communication coding was drawn to contain 81.8% cases with initial severity rating of moderate or major and 18.2% cases with an initial severity rating of no or minor effect, where the entire population consisted of cases with an initial severity rating of 5.7% moderate or major outcome and 94.3% no or minor effect. This stratification maximizes the ability to detect differences for cases where the initial severity was perceived to be moderate or major, while preserving the ability to detect differences among age groups. The coded calls were compared on case and call characteristics using regression analysis. The mean call lengths of high volume and low volume period calls were calculated.

Toxicall[®] electronic records were linked to the digital voice recordings of the call.⁷ RIAS is a widely used medical coding system in which each statement or phrase, representing a distinct thought, is coded for both the caller and the SPI. Two coders used digital recordings and specialized direct-entry software to assign individual RIAS codes. A sample of recordings (11%) was coded by both coders to check for reliability; intercoder reliability correlations > 0.80 across codes. Codes were then combined into composites to represent different types of communication: *clinical information*, close-ended questions, open-ended questions, emotional talk, recommendations (SPI only), *relationship talk* (SPI only), and statements per speaker.³ Examples of these types of communication are found in Table 1. All coded calls from the parent study that occurred during the high call volume and low call volume times (see below) were analyzed.

Data analysis

We examined the nonnormal distributions for each of the three call volume variables for each 30-minute period over the course of the year to ensure meaningful representation of high volume and low volume characteristics. We used maximum likelihood estimation⁸ to fit probability distributions for in-call duration, cases per SPI, and calls per SPI. Potential probability distributions were selected by two criteria. (1) We wanted a broad class of parameterizations and (2) we wanted models that could be estimated under a reasonable time constraint for our dataset size. We performed “leave one out” cross-validation using a log likelihood scoring rule for each probability distribution⁹. Once a best fitting distribution was identified, all 30-minute periods in the year (n = 17,520) were labeled with the best fitting probability distribution's quantile (e.g. left cumulative probability). For example, if a 30-minute period was labeled with 0.99 left cumulative probability, then that period was “busier” than 99% of all 30-minute periods during the study.

Analyses were powered to detect odds ratios of 0.96/1.04 at 0.80 power and $\alpha = 0.05$.

For the lower cutoff on the high volume periods, we chose cases from any half-hour period with greater than 4.2 calls per SPI, which corresponds to a Weibull left probability of 0.99. Similarly for the upper cutoff on low volume periods, there were 296 cases in half hours with 0.33 calls per SPI. The 0.33 calls per SPI corresponded to a Weibull left probability of 0.3. These cutoffs were selected as a balance between the goals of maximizing clinical relevance and allowing an adequate sample size for analyses.

We compared case characteristics of human exposure calls received during high volume and low volume periods using logistic regression. All statistical analysis was performed using R: a language and environment for statistical computing.¹⁰

Results

A total of 65,346 incoming calls were received through the ACD and 47,034 new human exposure cases were documented during the study. Of the new human exposures, 511 occurred during high workflow half hours and 13,485 in low workflow half hours. Table 2 presents the results of the call volume variables for all 30-minute periods. Because the distributions are nonlinear, the ranges for each variable impart the most meaning. Fig. 1 illustrates the pattern of SPI workload activity by each variable over a 1-week period.

Identifying best fitting probability distributions

Cross-validation scores measure the error between a prediction and an unobserved (e.g. left out) data point.¹¹ The optimally fitting probability distribution for *calls per SPI* was the Weibull distribution. The optimal fit for the number of *cases per SPI* was also Weibull. The optimal fit for *in-call duration* was the Gamma distribution.

While cross-validation scores were able to select the best fitting distribution for each variable, because of varying metrics, they should not be used for comparisons between variables. In order to most accurately identify high volume conditions, we were primarily concerned with fit for relatively high values of the three SPI workload variables (upper right quadrant of Fig. 2a–c). Fig. 2a shows that the best fitting of all results was the Weibull distribution for the Calls per SPI data series, so this variable was chosen as the best parameter to represent SPI workload.

Comparison of high volume and low volume periods

Call and case characteristics—In order to compare characteristics of high volume and low volume 30-minute periods, we defined 30-minute periods with more than 4.2 calls per SPI, with a Weibull left probability greater than 0.99 as high volume. Thirty-minute periods with less than 1.33 calls per SPI had a Weibull left probability of 0.30 and were identified as low volume periods. There were 42,049 calls that were omitted from analysis because they occurred in neither high nor low volume periods.

We compared characteristics of calls received during high and low volume 30-minute periods using logistic regression (Table 3). High volume periods were less likely to involve

“Intentional” as a reason for exposure, more likely to involve patients less than 6 years of age, occur during the winter months, and occur between 3 and 11 pm.

Call communication

From the parent study, 338 communication coded human exposure calls occurred during the high volume and low volume periods designated above (42 high volume, 296 low volume). The communication coded calls represent 3.2% (2.2% of the high volume, 3.8% of the low volume) of the calls that occurred during these periods. The shaded areas in Fig. 3 show the areas of the distribution from which these calls were selected. Mean call lengths for communication coded samples was 3 minutes 27 seconds (SD = 1 minute 46 seconds) during high volume and 3 minutes 57 seconds (SD = 2 minutes 11 seconds) during low volume periods.

Calls were not randomly selected from all available calls during high volume and low volume periods; they were sampled for high initial SPI severity and age for other primary analyses. The coded calls were compared on case and call characteristics using regression analysis. The communication coded subsample did not differ from the noncoded sample for any other clinical or call characteristics.

Table 4 shows the descriptive results for communication behaviors for low volume and high volume communication coded calls. The column furthest right shows the mean proportion of a specific composite to all speaker statements. For example, across all calls, SPIs devoted an average of 16% of talk to providing *clinical information*. Using logistic regression analysis, we examined the mean proportion of talk variables for SPI and for callers to assess for differences between high volume and low volume time periods. Regression analyses revealed a trend for fewer statements by both SPIs and callers during high volume periods ($p = 0.10$). No significant differences were found in caller communication between high volume and low volume times. SPIs asked more *closed-ended questions* during high volume times ($p < 0.01$), but SPI emotional talk, partnership talk, open-ended questions, clinical information, recommendations, and *total number of utterances* did not differ between high volume and low volume cases. Post-hoc power analyses revealed adequate power to detect differences.

Discussion

The capacity for PCCs and other emergency call centers to competently handle a sudden increase in the number of calls is an important function. As seen in Fig. 1, high call volume periods are unpredictable and uncommon events, making them difficult to study. In order to systematically evaluate the potential impact of high volume call periods on PCCs, we used data collected for a larger study^{3–5} to identify the most active periods (99th percentile) of SPI activity as high volume time based on call volume. We evaluated five statistical models (probability distributions) and found that the Weibull distribution for “calls per SPI per 30-minute period” most consistently identified time periods that were busier than 99% of all other time periods. This method identified 100 30-minute time periods during 12 consecutive months of call activity as high volume for this poison center.

We were able to compare the call characteristics during high volume periods to low volume periods and found more pediatric (age < 6 years) and fewer 'Intentional' exposures occurring during the high volume periods. These two variables are likely related, as most childhood exposures are unintentional. There was no difference in the medical outcome or number of cases involving more than one substance.

During high volume times, SPIs tended to be economical with speech and asked more direct questions, but maintained caller relationship-building communication behaviors such as partnering and emotional responsiveness. This suggests that while SPIs were focused on gaining information to determine and potentially solve the clinical problem, they did not lose sight of caller relationship building. This is important particularly for callers from the lay public who may need more trust building to facilitate information exchange than health care workers.

Despite efforts to adequately staff PCCs and other health-related call centers according to call volume, there will be periods when call volume exceeds staff capacity to immediately respond, even if only for a relatively short period. By assessing statistical approaches to quantify high volume conditions over the course of the year, we found that 4.2 calls or more per SPI per 30-minute period occurred only 1% of the time in our center. Variations in this high volume indicator may occur among PCCs based on staffing patterns, population of catchment area, utilization rates of the center by the general public and health care providers, and individual SPIs' ability to handle calls efficiently. Nevertheless, it is the identification of these time periods that represent potential strain on the systems, rather than the absolute number of calls per SPI that is important.

There were small differences found in communication between high volume and low volume periods in this study. We were unable to determine whether the types of communication used were the most effective for the situation or whether different types of communication should have been implemented. Future research is needed to determine effectiveness.

The model we utilized is one approach for PCCs, and possibly other call centers, to identify and quantify relatively high workload periods. Such data allows the study of call characteristics, operational and personnel performance during these periods. The 30-minute high volume conditions identified in the current study occurred on average once every 48 hours. If a PCC is able to routinely flag high volume periods, they can become part of a quality control review program. Staff will be able to reflect upon their performance and share strategies for maintaining quality care during high volume conditions. Such discussions may promote ongoing staff confidence and competence in handling high volume conditions.

Limitations

The results of the findings should be interpreted with caution. This study was performed at one US PCC with a clinical staff of 14 SPIs and may not be applicable to all PCCs. The characteristics of human exposure calls to the Utah PCC are similar to the US average for PCCs with two exceptions: there are relatively more cases involving children under 6 years of age (US 51% vs. Utah PCC 61%) and a lower major effects and fatalities outcome (US

0.8% vs. Utah PCC 0.4%). The call logger recorded variables at 10-second intervals. Changes that occurred in less than 10 seconds were not detected. The ACD captures the vast majority of calls and is a conservative estimate of call volume. There are rare times when calls are received directly to the phone outside the ACD line and would not be detected. Outgoing calls made by the staff were not captured by the ACD system and were not counted. This may underestimate the call work load, but follow-up call timing is more flexible than incoming calls and can be adjusted by staff during busy periods. The number of dropped calls during the high volume periods was not exported from the ACD at the time of this study, but would be valuable information to collect in a future study. The methodology requires specific hardware and software additions to the typical call center environment in order to be implemented. The calls coded for communication behaviors were available from the parent study and do not represent a random selection of all calls that occurred during high volume and low volume periods, but rather are selected primarily for severity level and age. Therefore, communication results could become biased if there is a three-way interaction between communication, workload and age or between communication, workload and initial SPI severity. Additionally, due to the focus on lay callers, these results may not apply to communication with health care providers.

Conclusion

We demonstrated a method for identifying periods of high workload for PCC staff. We found that call characteristics were similar and SPIs were able to maintain communication patterns despite the added stress of high call volume. This methodology has potential for use in the evaluation of SPIs communication skills and handling of calls during busy periods.

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Fig. 1.
Three indicators of SPI workload for a randomly selected week.

Fig. 2.
Probability distribution best fits for high volume call variables

Fig. 3.
The distribution of calls per SPI highlighting both high and low SPI workload periods in logarithmic scale.

Table 1

Examples of RIAS communication composite codes.

Code	SPI Example	Caller Example
Clinical information	"Eating a single silica packet won't make your son sick."	"He took the pills an hour ago."
Recommendations	"Flush his eyes with cold water."	–
Open questions	"How are you feeling now?"	–
Closed questions	"Do you feel nauseous?"	"Can that amount of Tylenol damage his liver?"
Emotional talk	"I know you're upset, but try to calm down."	"I feel so guilty for leaving the medication out where he could get it."
Relationship talk	"Let's think about who else could drive you to the ED; is there a neighbor at home?"	–

Table 2

SPI workload for 30-minute time periods.

Workload Variable	Range	Mean	Standard Deviation
Cases per SPI/30 minutes			
All 30-minute periods	0.2–21.0	1.95	1.42
High volume periods	0.3–10	3.39	1.50
Low volume periods	0.2–21	2.44	1.97
Calls per SPI/30 minutes			
All 30-minute periods	0–6.5	1.74	0.29
High volume periods	4.3–6.5	4.69	0.37
Low volume periods	0–1.3	0.83	0.44
In-call Duration (minutes)			
All 30-minute periods	0–27.0	5.3	0.85
High volume periods	3–20	10.36	3.37
Low volume periods	0–27	3.13	2.65

SPI: specialist in poison information.

In-Call Duration and Calls per SPI include both informational calls and exposure calls and exclude calls made directly to a particular workstation bypassing the ACD and any outgoing calls made by the SPI.

Cases per SPI include both informational and exposure cases.

Table 3

Likelihood of call characteristics for human exposure cases occurring during high volume compared with low volume periods.

Call Characteristic	Odds Ratio (95% Confidence Interval)
Moderate or major outcome	0.90 (0.73, 1.1)
More than one substance per case	0.45 (0.14, 1.4)
Caller is family member of patient	1.07 (0.87, 1.4)
Reason for exposure is intentional	0.70 (0.51, 0.97)
Route of exposure is ingestion	1.15 (0.89, 1.21)
Patient's age < 6 years	1.60 (1.20, 2.16)
Winter season (Dec, Jan, Feb)	3.07 (2.55, 3.71)
Weekend (Sat, Sun)	0.89 (0.75, 1.07)
Day shift (7:00 am–3:00 pm)	0.08 (0.05, 0.13)
Evening shift (3:00 pm–11:00 pm)	3.00 (2.50, 3.59)

Table 4

Communication descriptives for low volume, high volume, and all calls.

	Low Volume Calls N = 296				High Volume Calls N = 42				All Communication Coded Calls N = 338			
	Range	Mean Freq	Mean %	Std. Dev	Range	Mean Freq	Mean %	Std. Dev	Range	Mean Freq	Mean %	Std. Dev
SPI												
Clinical information	0.00–88.0	10.19	16%	0.09	0.00–36.0	9.69	17%	0.09	0.00–88.0	10.14	16%	0.09
Recom-mendations	0.00–25.0	4.27	7%	0.05	0.00–8.0	2.87	6%	0.04	0.00–25.0	4.13	7%	0.05
Open questions	0.00–18.0	1.67	3%	0.03	0.00–6.0	1.23	2%	0.02	0.00–18.0	1.63	3%	0.03
Closed questions	1.00–33.0	12.35	22%	0.08	3.00–25.0	12.08	5%	0.10	1.00–33.0	12.32	22%	0.08
Emotional talk	0.00–15.0	1.91	3%	0.03	0.00–5.0	1.46	3%	0.03	0.00–15.0	1.86	3%	0.03
Relationship talk	1.00–53.0	11.88	19%	0.06	2.00–25.0	9.38	18%	0.06	1.00–53.0	11.64	19%	0.06
Total SPI talk	5.00–263.0	61.29		28.65	13.0–113.0	52.10		22.88	5.00–263.0	60.38		28.24
CALLER												
Clinical information	1.00–103.0	27.55	63%	0.12	9.00–47.0	23.97	63%	0.14	1.00–103.0	27.19	63%	0.13
Questions	0.00–20.0	1.88	4%	0.05	0.00–17.0	2.03	4%	0.04	0.00–20.0	1.90	4%	0.05
emotional talk	0.00–16.0	0.69		0.02	0.00–4.0	0.62	1%	0.02	0.00–16.0	0.68	1%	0.02
Total caller talk	3.00–179.0	44.98		22.08	14.0–85.0	39.92		17.66	3.00–179.0	44.47		21.72

Mean Freq: mean frequency.

SPI: specialist in poison information.