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Calls to Florida Poison Control Centers about Mercury: Trends over 2003–2013

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Abstract

Objective—The aim of this analysis was to contrast trends in exposure-report calls and informational queries (a measure of public interest) about mercury to the Florida Poison Control Centers over 2003–2013.

Materials and Methods—Poison-control specialists coded calls to Florida Poison Control Centers by substance of concern, caller demographics, and whether the call pertained to an exposure event or was an informational query. For the present study, call records regarding mercury were de-identified and provided along with daily total number of calls for statistical analysis. We fit Poisson models using generalized estimating equations to summarize changes across years in counts of daily calls to Florida Poison Control Centers, adjusting for month. In a second stage of analysis, we further adjusted for the total number of calls each day. We also conducted analyses stratified by age of the exposed.

Results—There was an overall decrease over 2003–2013 in the number of total calls about mercury [Ratio per year: 0.89, 95% CI: (0.88, 0.90)], and calls about mercury exposure [Ratio per year: 0.84, 95% CI: (0.83, 0.85)], but the number of informational queries about mercury increased over this time [Ratio per year: 1.15 (95% CI: 1.12, 1.18)]. After adjusting for the number of calls of that type each day (e.g., call volume), the associations remained similar: a ratio of 0.88 (95% CI: 0.87, 0.89) per year for total calls, 0.85 (0.83, 0.86) for exposure-related calls, and 1.17 (1.14, 1.21) for informational queries.

Conclusion—Although, the number of exposure-related calls decreased, informational queries increased over 2003–2013. This might suggest an increased public interest in mercury health risks despite a decrease in reported exposures over this time period.

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Keywords

Florida Poison Control Center; mercury; thermometer; risk perception; environmental psychology

INTRODUCTION

Mercury is an environmental toxicant that can occur in several forms (e.g., inorganic, elemental, methylmercury), each with distinct health risks (WHO, 2010). In the United States, the most common, but declining, source of pediatric elemental mercury exposure is broken thermometers (Bose-O'Reilly et al., 2010; Lee et al., 2009), which could impact public visibility of mercury exposures. Methylmercury exposure often comes from seafood (Karimi et al., 2012; Sheehan et al., 2014). Recent surveys in Florida indicate regional variability in mercury exposures, with a quarter of pregnant women in Martin County showing hair mercury $1 \mu\text{g/g}$ (Nair et al., 2014) but only 7% of participating women between the ages of 18–49 in Duval County showing hair mercury 1 pg/g (Traynor et al., 2013). A recent review of calls reporting exposures to the Texas poison control centers found an 89% decrease in exposure-reporting calls from 2000 to 2013 (Forrester, 2016), and national data suggest a decrease of 86% in mercury exposure-report calls between 2000 and 2013 (Litovitz et al., 2001; Mowry et al., 2014).

Patterns of actual exposures and health hazards may differ from the patterns of public concern about mercury. Survey research by Paul Slovic in the 1980s found that mercury was regarded as a “dread risk” and “unknown” risk, per his two-factor psychometric model for risk perceptions (Slovic, 1987); mercury thus fell in the quadrant of perceived risks for which public concern was highest. In addition to Slovic’s psychometric paradigm, social scientists have also used appraisal theory and other risk frameworks to investigate perceptions of mercury and other environmental hazards (Bostrom, 2008; Brown, 2014; Keller et al., 2012). Appraisal theory posits that considerations such as certainty and fairness influence emotional evaluations of environmental risks (Keller et al., 2012; Watson and Spence, 2007). Other psychological theories like the Risk Information Seeking and Processing Model and Social Amplification of Risk Model suggest that subjective norms and availability of information could also potentially influence mercury risk perceptions (Griffin et al., 1999; Kasperson et al., 1988; Yang et al., 2014). It is plausible that information about the sources, health effects, and severity of consequences of mercury exposure may have improved over time; mercury risk perceptions also may have changed.

There are limited data on how public perceptions of mercury may have evolved over the past several years. Perceptions of mercury exposure and risk may vary by sex, race, and other factors (Lin et al., 2014; Silver et al., 2007). A 2009 study that examined mercury risk perception among a subset of New England residents and in a U.S. nationally representative sample found varying degrees of risk perception, knowledge of mercury sources, and awareness of potential mercury exposures (Turaga et al., 2014). Based on national data from the Food Safety Surveys, awareness of mercury in seafood increased between 2001 and 2006 and the greatest awareness was in parents of children under age 5 (Lando and Zhang, 2011). Mercury-focused community outreach efforts such as fish consumption advisories, the

Agency for Toxic Substances and Disease Registry’s “Don’t Mess with Mercury” campaign, and nonprofit organization efforts seek to educate communities about the risks of mercury exposure (Engelberth et al., 2013; Watters and Rayman, 2014). However, in a recent survey of the region near Pensacola, Florida, only 31% of women were aware of the Florida Fish Consumption Advisory (Karouna-Renier et al., 2008).

We considered Florida Poison Control Centers’ historical record of calls about mercury as a novel and objective indicator for how the Florida public’s concerns about mercury exposures may have evolved over 2003–2013. Contrasting the informational queries against exposure-report calls provides greater context for understanding how perceptions may have evolved over time vis-à-vis reported exposures. The objective of this study was to summarize the temporal trends of calls about mercury to Florida Poison Control Centers over 2003–2013, overall and grouped into calls about exposure (an indicator of exposures that elicited concern sufficient for a call) or informational queries (an indicator of general public interest and concern about mercury).

METHODS

Data Source

Calls to the 1-800-222-1222 Poison Help® line in Florida are routinely entered into a standardized database (ToxSentry®, trademarked by the Grady Memorial Hospital Corporation and the University of Florida Health Sciences Center - Jacksonville) by the three poison centers that comprise the Florida Poison Information Center Network. These data are available for public data analysis once personal identifiers have been removed. The data from these calls prior to de-identification include identifiers such as date, specific substance, medical outcome, substance of concern, age, and sex. Data were collected both for calls about specific exposure events and on calls that are “informational” only.

Staff at the Florida Poison Information Center – Miami located the records of calls from 2003–2013 coded in ToxSentry® as involving mercury (i.e., searched for the entire category of “mercury” - AAPCC product code #0158000 - in the National Poison Data System), removed most individual identifiers (for this analysis, dates were retained), and provided summary information about each day’s calls, in particular: the age of the persons reportedly exposed, and the chemical motivating the calls [inconsistently coded text strings including “MERCURY”, “THERMOMETERS”, “MERCURY THERMOMETERS (GENERAL FORMULATION)”, “THERMOMETER, B-D BASAL FROM BECTON DICKENSON <UNITED STATES>”, “THERMOMETER, BABY RECTAL FROM SUPERX DRUGS <UNITED STATES>”, “THERMOMETER, ORAL FEVER FROM KROGER”, “MERCURY, ELEMENTAL”, “THERMOMETERS (MERCURY) (GENERAL FORMULATION)”, “MERCURY, ORGANIC”, “THERMOMETERS: MERCURY”, “MERCURY, OTHER” etc.]. We defined thermometer-related calls as calls whose description of the exposure included the character string “THERM” and then recoded “MERCURY (ELEMENTAL) (EXCLUDING THERMOMETER)” as not-thermometer related. This analysis was deemed “not human subjects research” by the Emory University IRB.

Statistical Methods

We evaluated the total number of calls about mercury each day, and also stratified calls based on whether they were informational queries or reports of possible exposure. For the purposes of describing the overall temporal trends in calls about mercury, there is a substantive rationale for simplifying all kinds of mercury exposure as “mercury”: mercury in the environment can gain or lose a methyl group (Celo et al., 2006; Choi and Bartha, 1994; Li and Cai, 2013) and mercury can also change methylation state in the gut and body (Parajuli et al., 2016; Rothenberg et al., 2016; Sherman et al., 2013). Furthermore, on a practical level, there may be inconsistencies in how calls about specific mercury species were recorded by poison control center specialists, so collapsing into a single category of mercury should reduce misclassification of the number of calls. Nonetheless, we recognize that differences between mercury-containing molecules are tremendously important for the biological effects of mercury, and that different sources of exposure are expected to lead to varying doses of different kinds of mercury. Aggregation of all kinds of mercury exposure also allows for clearer alignment of public *perceptions* of mercury risks with mercury exposures over time, as risk perception studies about mercury typically refer to “mercury” rather than to mercury species.

Two dates were extreme outliers, with those days’ calls predominantly reflecting unusual mass exposure events, and so for our main analysis those two days were re-coded to only include calls unrelated to the mass exposure events (leaving zero mercury exposure-related calls on 1/28/2003 and two mercury exposure-related calls on 11/20/2006). We also present results from sensitivity analyses without recoding these outliers. The data analysts for this project had restricted access to the detail of all calls over a decade, so we did not subtract other “group poisoning” events from our adjustment variable of the total number of calls about any compound per day.

Time-series of count data can be modeled as Poisson; if autocorrelation is present, it may be accounted for using generalized estimating equations (GEE) (Dominici et al., 2002; Schwartz et al., 1996; Zeger, 1988). We estimated Poisson GEE models with an independent autocorrelation structure (Liang and Zeger, 1986; Zeger, 1988) to summarize population-averaged trends in the total number of mercury-related calls, mercury exposure-reporting calls, and informational queries; and conducted sensitivity analyses for alternative assumptions about the correlation structure. We also conducted stratified analyses for exposure-related calls by patient age and by whether the call was coded as thermometer-related.

In secondary analyses, we conducted an analysis stratified by age of the person exposed to mercury in the call, to examine how the time trends of mercury exposure-related calls may differ by age. We excluded calls about persons for whom age was not reported, restricting our stratified analysis to 2,313 of the 2,944 exposure-related calls. For these secondary, descriptive analyses, we grouped participants into age categories that were small enough to be informative, but large enough to allow stable estimation.

RESULTS

The time-series of calls about mercury to Florida Poison Control Centers, overall and stratified by nature of the call, are shown in Figure 1. A variation on this figure excluding the outliers is available in Appendix 1. During the 4,108 days of observation in this decade, there were 3,573 mercury-related calls, of which 2,944 were exposure-related calls (82%) and 629 were informational queries (18%). In 2003, there were 469 total calls about mercury, while in 2013 there were 136 total calls about mercury. There is a major outlier of 189 mercury calls on January 28, 2003, and a second outlier of 32 mercury calls on November 20, 2006. Although analysts did not have access to detailed call records, review by the Florida Poison Information System staff uncovered that these call surges were related to mass-exposure mercury spill events in schools. There was a string of 761 days at the beginning of observational period where no informational calls were placed about mercury, however there were informational calls pertaining to other substances during this period (minimum number of informational queries overall in a day including all substances was $n=33$). Mercury calls were at no point in time a major volume of the total number of daily informational queries; at its highest point, there were only 4 calls requesting information about mercury in a single day. The mean number of total mercury-related calls each day was 0.89, of exposure-related calls was 0.73, and informational queries was 0.16; the median number of total mercury calls was 1 (25th and 75th percentiles: 0, 1), exposure calls was 0 (25th and 75th percentiles: 0, 1), and informational queries was 0 (25th and 75th percentiles: 0,0). The majority ($n=1,894$, or 64%) of mercury exposure-related phone calls over 2003–2013 interval were thermometer-related.

Recoding the two days' calls related to mass exposure events to reduce the influence of outliers, and assuming an independent correlation structure, we found an overall decrease (Table 1) over 2003–2013 in the number of total calls about mercury [Ratio per year: 0.91, 95% CI: (0.90, 0.92)], and calls about mercury exposure [Ratio per year: 0.86, 95% CI: (0.85, 0.87)]. Adjusting for the number of calls of that type each day, to control for temporal variation in the utilization of the poison control center hotline, yielded similar results [exposure calls ratio per year: 0.91 (0.90, 0.92); total calls ratio per year: 0.86 (0.85, 0.88)]. These results were robust to various specifications of the autocorrelation structure (Appendix 2), and associations were similar when including the two mass-exposure outliers (Appendix 3). The decrease was seen both among thermometer-related exposure calls and calls unrelated to thermometers (Table 2).

There was an increase (Table 1) in the number of informational queries about mercury over time [Ratio per year: 1.15 (95% CI: 1.12, 1.18); adjusted for any-compound queries: 1.17 (1.14, 1.21)]. This increase in calls about mercury was partly attributable to a string of days at the start of this time window when there were no informational calls about mercury, but even restricting to afterwards, there was a temporal increase over the remaining 3,255 days [Ratio per year adjusted for month: 1.05 (95% CI: 1.02, 1.08)]. This association was slightly stronger after controlling for the total volume of informational calls each day: 1.07 (1.04, 1.11)].

The age-stratified analysis (Figure 2) found a more extreme reduction in the number of calls among persons 60 years old: the ratio per year adjusted for month in that subgroup was 0.84 (95% CI: 0.81, 0.86). There were also significant negative associations among persons 18–35 years of age, and 45–60 years of age; and suggestive negative associations among several other age groups.

DISCUSSION

This time-series analysis of a decade's worth of calls to Florida Poison Control Centers found a decrease in the volume of mercury exposure-related calls over 2003–2013. The apparent decrease in exposure-related calls are consistent with similar trends over this time period observed in Texas and nationally (Forrester, 2016; Litovitz et al., 2001; Mowry et al., 2014), and might reflect a true reduction in mercury exposures, but the frequency of phone contact to the poison control centers concerning mercury exposures does not necessarily track the frequency of mercury exposures in Florida. Although the reduction in thermometer-related calls, which were the majority of exposure-report calls for mercury over the study period, is consistent with the declining importance of thermometers nationally as a source of children's exposure (Lee et al., 2009), it is likely that not all exposure events are reported via calls to Florida Poison Control Centers. Some studies have shown that factors such as race, language, proximity to a poison control center, and season may contribute to whether a person may call a poison control center (Albertson et al., 2004; Litovitz et al., 2010). Risk perception, information resources, and awareness may also influence contact to a poison control center. There may be changes over time in the availability of mercury informational materials, for example the "Don't Mess with Mercury" campaign began in 2010 [23]. However, risk perceptions are complicated by influence from emotions, past behavior, and sociodemographic variables (Brown, 2014; Flynn et al., 1994). Utilization and pursuit of information about environmental risk may be affected by variables such as preference, relevance, motivation, accessibility, information sufficiency, self-efficacy and environmental health literacy (Griffin et al., 1999; McCallum et al., 1991). The time-series study design's control for geography, and this analysis's regression modeling control for temporal confounders (e.g., any possible differences in Florida Poison Control Centers' penetrance over time), should lead to an accurate summary of mercury-related phone call patterns as a measure of public concern at the Florida state level. However, this time-series study design has major limitations understanding individual-level psychology and behavior. In order to better understand factors that contribute to why a person may call a poison control center related to mercury, formative research may be helpful to understand health beliefs, affective response, information sufficiency and information factors that may amplify mercury risk perceptions and exposure-related behaviors (Turner et al., 2011).

These associations were robust to adjustments and alternative assumptions about the correlation structure; but there are some limitations to the data. This is the complete population of calls to Florida Poison Control Centers over this decade, so selection bias is not a concern for our inference about trends in calls to the Florida Poison Control Centers. However, extrapolation more broadly to "public" attitudes and exposures in Florida is limited by the selection process that drives some people, but not all, to make phone calls to Florida Poison Control Centers (Dart et al.). There are other numbers that a concerned

Floridian could have called: for example, the hotline to report a spill or other hazardous material release Florida Division of Emergency Management's State Watch Office is 1-800-320-0519; and the Florida Department of Health has a hotline at 1-877-798-2772 that may prove helpful to persons seeking information on air testing contractors and mercury cleanup. There is potential for selection and information bias in the stratified analysis, in particular due to possible inconsistencies in data-coding due to variation in training or coding practices across the three participating centers in Florida. Age of the person motivating the call was sometimes recorded in ToxSentry® as a range (i.e., “ 5 years”, “ 19 years”) which we excluded from our age-stratified analysis, imposing a small selection bias. There may also be some misclassification of exposure calls as not thermometer-related when exposures were, in fact, due to thermometers. Lastly, we had limited ability to assess whether awareness campaigns influenced the volume of informational queries, as there were only at most 4 informational queries about mercury on the highest-intensity date; to reliably detect a difference-in-slope attributable to national informational campaigns (i.e., “Don't Mess with Mercury” [23]) would require more data pooled from additional states.

It appears from the age-stratified calls that participants 60 years old had a stronger decrease in exposure-related calls over the time period 2003–2013, although decreases were also seen over time in several other age categories. The steeper decrease in the number of calls over time among persons age 60 years old is especially interesting in light of the fact that older adults generally underutilize the poison control center relative to other population groups (HRSA, 2012). We speculate that this observed time trend could reflect a change in membership of this age group over time (e.g., a cohort effect of younger people aging into the oldest demographic group as some of the older members die), in the context of concurrently declining exposures to which older people may have special exposure pathways - for example, if there were a higher frequency of exposure to broken mercury thermometers in older persons' living spaces compared to younger persons. In this hypothetical scenario, a decrease in the number of calls among persons 60 years old over time might reflect fewer among the persons age 60 years old owning mercury thermometers over time. Another speculated explanation for the exposure-concerned calls is that as older people receive medical testing, perhaps they may have incidental findings of higher mercury biomarkers (these are older people who may have a longer history of eating seafood, and methylmercury bioaccumulates); however, this would raise questions about the frequency of testing for mercury over time. Additional research on specific kinds of mercury exposure among Floridians, by age group, as well as data on possible trends in prescribing of laboratory tests for blood mercury, could explore potential mechanisms underlying the observed differences in call patterns among persons 60 years old. Florida has a larger proportion of adults over age 65 than the U.S. average (19.9% vs. 15.2%) so possible changes in exposure among the elderly may be especially relevant to public health in that state (United States Census Bureau, 2017).

CONCLUSIONS

There was an annual decrease in calls about mercury exposures and an annual increase in informational queries about mercury in Florida over the decade 2003–2013. This decline in

mercury exposure-related calls appeared especially strong among the oldest age group (age 60 years).

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

1. Informational queries about mercury to the Florida Poison Control Centers increased over 2003–2013.
2. Exposure-related calls about mercury to the Florida Poison Control Centers decreased over 2003–2013.
3. Decreases in exposure-related calls over 2003–2013 were most pronounced among persons \geq 60 years old.

Mercury Calls to the Florida Poison Control Center, 2003-2013

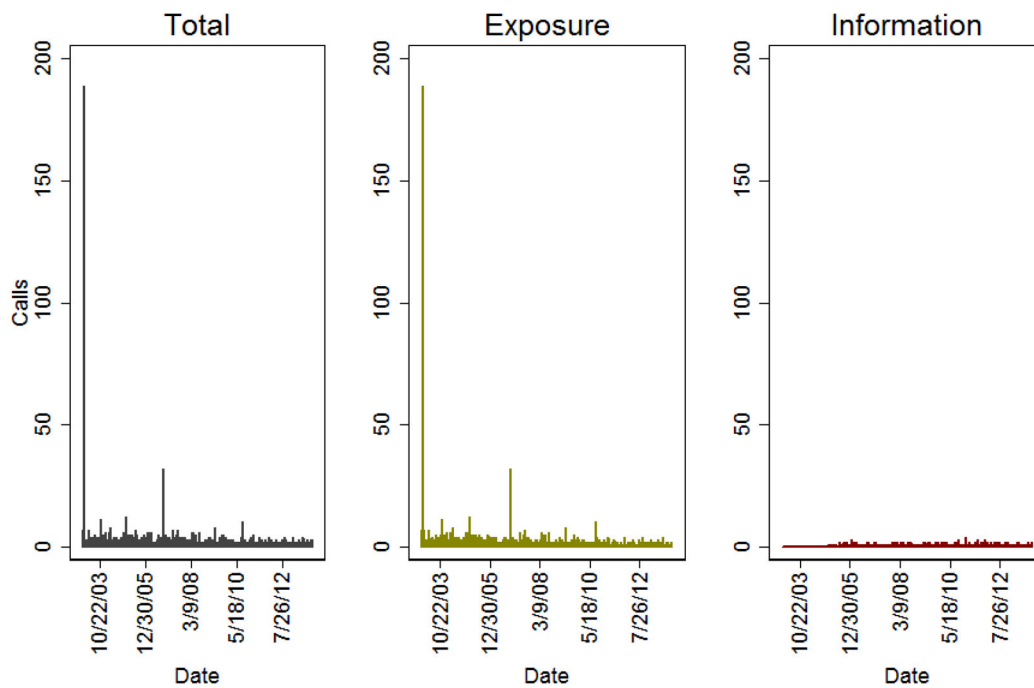


Figure 1. Complete time-series of mercury-related calls, 2003–2013

There were two high outlier days (189 calls on January 28, 2003; and 32 calls on November 20, 2006) reflecting mass exposure events in schools; for this reason, temporal trend statistical analyses were conducted including all data, and excluding the mass exposure-related call surges.

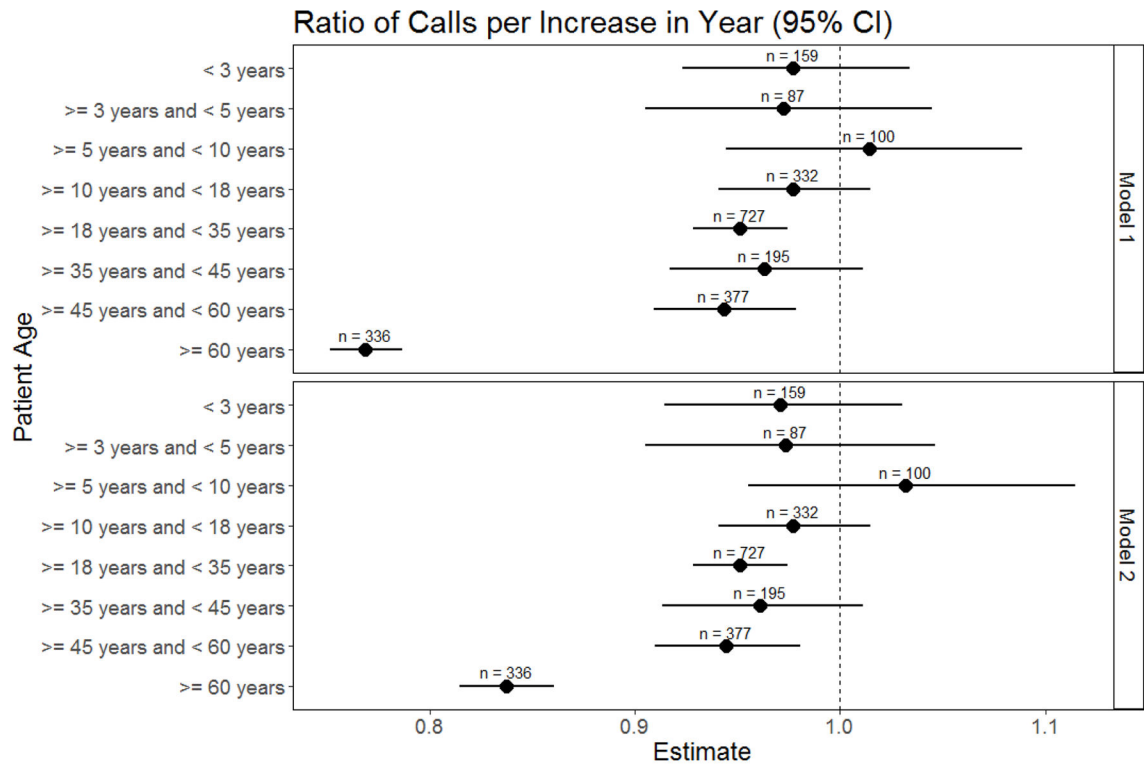


Figure 2. Ratio of mercury exposure-related calls per year, by age of the person motivating the call

Models were fit as Poisson (Independent) GEE. We included calls related to two high-outlier call volume, mass-exposure events in this analysis for age-related trends because the mass-exposures occurred at schools and therefore that exposure process might be age-related. Only persons with known ages were included in this stratified analysis (we included ages reported within a range if the full range fell within one of our strata); thus 2,313 of the 2,934 exposure-related calls were included. Model 1 adjusts for year (linear) and month (dummy variables). Model 2 further adjusts for the total number of exposure-related calls.

Table 1
Estimated trends in calls to the Florida Poison Control Center about mercury: 2003–2013, excluding outliers

Models were fit as Poisson (Independent) GEE, with linear term for calendar year and dummy variables for each month. Model 2 further adjusted for all-chemical calls of that type per day. We recoded the total number of calls, and exposure-related calls, to exclude calls related to two mass exposure events at the beginning of the study period for this analysis for general trend. We included the stretch of dates at the beginning of the observational period with zero informational queries about mercury because there were informational queries about other substances during that time.

Type of Call	Calls*	Ratio of Calls per Increase in Year (95% CI)	
		Model 1	Model 2
Total Mercury-Related Calls	3,345*	0.91 (0.90, 0.92)	0.91 (0.90, 0.92)
Exposure-Related Calls	2,815*	0.86 (0.85, 0.87)	0.86 (0.85, 0.87)
Informational Query	629	1.15 (1.12, 1.18)	1.17 (1.14, 1.21)

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Table 2
Estimated trends in exposure-related calls, whether coded as thermometer-related or not

Models were fit as independent Poisson GEE, with linear term for calendar year and dummy variables for each month. Model 2 further adjusted for the total any-compound, exposure-related calls to the centers per day. We included calls related to two high-outlier call volume, mass-exposure events in this analysis for relative importance of thermometers to volume of exposure-related calls.

Exposure-Related Call Type	Calls	<u>Ratio of Calls per Increase in Year (95% CI)</u>	
		Model 1	Model 2
Thermometer-Related	1,894	0.84 (0.83, 0.85)	0.84 (0.83, 0.85)
Not Thermometer-Related	1,050	0.84 (0.83, 0.86)	0.87 (0.85, 0.89)

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