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# Preventing Battery Ingestions: An Analysis of 8648 Cases

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# Preventing Battery Ingestions: An Analysis of 8648 Cases

**WHAT'S KNOWN ON THIS SUBJECT:** Button battery ingestion outcomes have worsened as a result of increased use of 20-mm-diameter lithium coin cells. Esophageal perforation, tracheoesophageal fistulas, exsanguination after fistulization into blood vessels, esophageal strictures, vocal cord paralysis, and deaths have been reported.

**WHAT THIS STUDY ADDS:** In children, ingested batteries were removed directly from products in 61.8% of cases, loose or discarded in 29.8%, and obtained from the packaging in 8.2%. Battery compartments must be secured, especially when they contain ≥20-mm cells.

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**KEY WORDS**
disc battery ingestion, button battery ingestion, primary prevention, injury prevention

**ABBREVIATION**
NBIH—National Battery Ingestion Hotline

The views in this article are those of the authors and do not necessarily represent the views of the National Electrical Manufacturers Association.



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## abstract

**OBJECTIVES:** Outcomes of pediatric button battery ingestions have worsened substantially, predominantly related to the emergence of the 20-mm-diameter lithium cell as a common power source for household products. Button batteries lodged in the esophagus can cause severe tissue damage in just 2 hours, with delayed complications such as esophageal perforation, tracheoesophageal fistulas, exsanguination after fistulization into a major blood vessel, esophageal strictures, and vocal cord paralysis. Thirteen deaths have been reported. The objective of this study was to explore button battery ingestion scenarios to formulate prevention strategies.

**METHODS:** A total of 8648 battery ingestions that were reported to the National Battery Ingestion Hotline were analyzed.

**RESULTS:** Batteries that were ingested by children who were younger than 6 years were most often obtained directly from a product (61.8%), were loose (29.8%), or were obtained from battery packaging (8.2%). Of young children who ingested the most hazardous battery, the 20-mm lithium cell, 37.3% were intended for remote controls. Adults most often ingested batteries that were sitting out, loose, or discarded (80.8%); obtained directly from a product (4.2%); obtained from battery packaging (3.0%); or swallowed within a hearing aid (12.1%). Batteries that were intended for hearing aids were implicated in 36.3% of ingestions. Batteries were mistaken for pills in 15.5% of ingestions, mostly by older adults.

**CONCLUSIONS:** Parents and child care providers should be taught to prevent battery ingestions. Because 61.8% of batteries that were ingested by children were obtained from products, manufacturers should redesign household products to secure the battery compartment, possibly requiring a tool to open it. *Pediatrics* 2010;125:1178–1183

We recently demonstrated an alarming trend toward profoundly worsened outcomes from button battery ingestions.[1] Although the annual incidence of battery ingestions reported to US poison centers from 1985 to 2009 fluctuated up and down between 6.3 and 15.1 cases per million population (most recently at 11.1 cases per million in 2009), there was no clear incidence trend. In contrast, a 6.7-fold increase in the percentage of ingestions with major or fatal outcomes was observed during this period. The increase in severity was attributed to the emergence of the 20-mm-diameter lithium coin cell as an increasingly popular battery type. Thirteen deaths related to tissue damage in the esophagus or airway and 73 major outcomes (with debilitating and prolonged compromise of feeding and/or breathing that required multiple surgical procedures, tube feedings, and/or tracheostomies) were described. These devastating cases occurred predominantly in children who were younger than 4 years.

Although a change in the clinical approach to battery ingestions will be required to avoid misdiagnosis or delayed treatment, the primary prevention of battery ingestions would be even more effective than improved treatment. This investigation was undertaken to explore reported ingestion scenarios to identify ways to focus prevention education and formulate prevention strategies.

## METHODS

The National Battery Ingestion Hotline (NBIH; accessed by calling 202-625-3333) was established in 1982 at the National Capital Poison Center to provide 24/7 telephone treatment guidance for the public and health professionals who manage battery ingestion cases. The service also provides public health surveillance of battery ingestions to identify emerging hazards and develop and update triage and treatment guidelines to optimize patient outcomes. Health care providers, parents, and battery ingestors become aware of the service through notices on battery packages and product instructions, Web resources, the medical literature, audiologists, poison prevention information, and referrals from industry and poison centers.

Cases that were reported to the NBIH through June 1990 were previously reported.[2–4] This investigation focuses on all button and cylindrical battery ingestions reported to the NBIH between July 1, 1990, and September 30, 2008. The NBIH data supplement the standard poison control data set with detail on clinical course, battery characteristics, and ingestion scenario.

Data were collected by Specialists in Poison Information by using the Toxicall interface, then analyzed by using SQL and Excel. The analysis focused on patient age, battery diameter and chemistry, source of the battery (loose, in product, in manufacturer's packaging), intended use of the battery, and the ingestion scenario. This study was exempted from full review by the Georgetown University institutional review board.

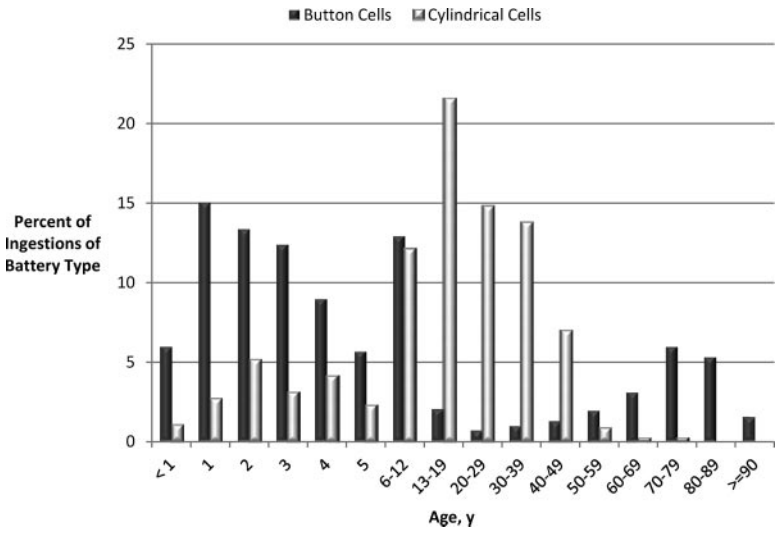


**FIGURE 1**
Age distribution of battery ingestions for button versus cylindrical cells.

## RESULTS

During the 18.25-year study period, 8648 battery ingestion cases were reported to the NBIH, including 8161 button batteries and 487 cylindrical cell ingestions (eg, AA, AAA). Cases were reported from the United States (97.1%) and 47 other countries.

Button cell ingestions were most common at the extremes of age, with peak frequencies in 1- to 3-year-olds and in the elderly (Fig 1). Children who were younger than 6 years were involved in 62.5% of button cell ingestions; another 15.9% involved adults who were aged ≥60 years. In contrast, 62.2% of cylindrical battery ingestions occurred in 6- to 39-year-olds, with the peak frequency seen among teens. The proportion of males was higher for cylindrical cell ingestions (63.8%) compared with 56.8% of button cell ingestions ($\chi^2$, $P = .0025$).

Of ingested button batteries with known diameter, 4 sizes were especially popular during the 18.25-year study period: 11.6 mm (55.1%), 7.8 to 7.9 mm (30.6%), 20 mm (6.4%), and 5.8

mm (3.0%). By 2008, however, 18% of ingested batteries (with known diameter) were ≥20 mm, and in the current market, virtually all of these large diameter cells are lithium cells.

## NBIH: Battery Ingestion Scenarios

Immediately before ingestion, batteries were removed directly from a product (45.5%, of 6733 with known source); sitting out, loose, or discarded (44.9%); or removed from the manufacturer's packaging (6.3%). In 221 (3.3%) cases with known source, batteries were ingested in a hearing aid (whole aid swallowed). In children who were younger than 6 years, batteries were most often obtained directly from a product (61.8%, of 3989 pediatric ingestions with known source), loose in 29.8%, obtained directly from the battery packaging in 8.2%, and swallowed within a hearing aid in 0.2%. In contrast, adults (≥20 years) most often ingested batteries that were sitting out, loose, or discarded (80.8%, of 1634 adult ingestions with known source); obtained directly from a product in only 4.2%; obtained from battery packaging in 3.0%; and swallowed within a hearing aid in 12.1%.

**TABLE 1** Intended Use of Ingested Batteries (NBIH, July 1990 to September 2008)

| Intended Use of Ingested Battery | *n* | % of Known |
|---|---|---|
| Hearing aid (2514) or cochlear implant (14) | 2528 | 36.27 |
| Game/toy | 1538 | 22.07 |
| Watch | 775 | 11.12 |
| Calculator | 400 | 5.74 |
| Flashlight/light/lantern/laser light/laser pointer/nightlight/penlight | 320 | 4.59 |
| Remote control (television, garage door, key fob) | 200 | 2.87 |
| Key chain: laser, flashlight, whistle, toy, calculator, laser pointer | 167 | 2.40 |
| Clock/clock radio/timer/stopwatch | 125 | 1.79 |
| Jewelry (flashing, lighted, musical, tongue ring, earring, necklace) | 121 | 1.74 |
| Book | 116 | 1.66 |
| Camera | 112 | 1.61 |
| Telephone/pager | 81 | 1.16 |
| Noisemaker | 76 | 1.09 |
| Pen (lighted, laser) | 60 | 0.86 |
| Miscellaneous (badge, candle, cup, fishing lure, door chime, dog collar, electric meter, battery charger, gun scope, invisible fence, lighted eraser, lighted tweezers, lighted whistle, mat/rug, mirror light, picture frame, printer/scanner, scale, teapot, toothbrush, tool, trophy, Wi-Fi locator) | 48 | 0.69 |
| Music or video players/recorders/microphones/headphones (cassette, CD, DVD, walkman, iPod, MP3 player, Tivo) | 38 | 0.55 |
| Radio | 32 | 0.46 |
| Computer/PDA | 29 | 0.42 |
| Thermometer | 29 | 0.42 |
| Attire (flashing, lighted, or musical barrette, buckle, costume, glove, shoe, shoelace, sock, sun glasses, button, body light) | 26 | 0.37 |
| Musical instrument (guitar, flute, piano) | 24 | 0.34 |
| Exercise equipment | 22 | 0.32 |
| Book light, book mark | 20 | 0.29 |
| Magnet (lighted, flashing) | 16 | 0.23 |
| Greeting card | 15 | 0.22 |
| Ornament | 15 | 0.22 |
| Alarm/monitor (auto, baby, bedwetting, door, motion, window) | 14 | 0.20 |
| Bicycle equipment/light | 12 | 0.17 |
| Medication pump, medical equipment | 11 | 0.16 |
| Total known | 6970 | 100.00 |
| Unknown | 1678 | |
| Total | 8648 | |

The most common intended uses of ingested batteries (Table 1) were hearing aids (36.3%, including cochlear implants), games and toys (22.1%), watches (11.1%), calculators (5.7%) flashlights and other pointers and lights (4.6%), remote control devices including keyless entry fobs (2.9%), and key chains (2.4%). Batteries were also ingested from a multitude of unexpected sources: toothbrush, bedwetting monitor, lighted shoe, bookmark, flashing or musical jewelry, digital thermometer, scale, and many others (Table 1). Ingested hearing aid batteries belonged to the ingestor in 83.6% of cases (with known owner). Of 208 ingestions of 20-mm-diameter lithium cells by children who were younger than 6 years, 37.7% (55) were intended for remote controls (of the 70.2% of cases with known intended use); 15.1% for games or toys; 7.5% for calculators; 5.5% for watches; 4.8% for computers or personal digital assistants; 4.1% for thermometers; 4.1% for cameras; and the remainder from a full range of sources, including attire, bicycle equipment, books and book marks, exercise equipment, greeting cards, jewelry, key chains, medical equipment, and telephones. Of the 55 ingestions by children who were younger than 6 years and involving 20-mm lithium cells intended for remote controls, 65.2% were obtained from the product by the child; 28.3% were found sitting out, loose, or discarded; and 6.5% were obtained from the product or battery packaging.

Of all ingestions, 15.5% occurred because batteries were mistaken for pills (Table 2); 92.1% of these batteries were intended for hearing aids. Patients typically swallowed batteries that were stored near or with pills, with water, or reached into a pocket for a pill and swallowed a battery that was also in that pocket. A number of these patients swallowed a hearing aid battery then put their pill into their hearing aid, noting the error either when the pill did not fit or the aid did

**TABLE 2** Recurring or Unusual Ingestion Scenarios

| Ingestion Scenario | *n* | % of Cases |
|---|---|---|
| Mistook battery for a pill | 1337 | 15.46 |
| Mistook hearing aid with battery in it for pill | 101 | 1.17 |
| Suicidal or other intentional ingestion in patient with mental illness | 224 | 2.59 |
| Cognitive impairment or neuropsychiatric disorder (ingestion not known to be intentional) | 127 | 1.47 |
| Ingestion realized only after battery found in stool or diaper | 75 | 0.87 |
| Used mouth to hold battery | 67 | 0.77 |
| Thought battery was food[a] | 63 | 0.73 |
| Placed in mouth to test or for "shock" | 52 | 0.60 |
| Incarcerated patient | 40 | 0.46 |
| Removed discarded battery from trash | 18 | 0.21 |
| Ingested battery on a dare | 14 | 0.16 |
| Performing a trick | 10 | 0.12 |
| Swallowed battery to "glow," "morph," or be more energetic | 6 | 0.07 |
| Removed battery from toy to silence the toy | 4 | 0.05 |
| Used teeth to pull tab off zinc-air battery to activate it | 2 | 0.02 |

[a] Commonly ingested with or instead of candy, nuts, or popcorn; or batteries placed in glass later used for drinking.

not function. Although patients of all ages indicated that they mistook batteries for pills, 89.2% were ≥50 years and 63.2% were ≥70 years (mean: 70.6 years; median: 74.0 years; SD: 15.9 years). Another 1.2% of all ingestions involved entire hearing aids ingested when the whole aid was mistaken for a pill.

## DISCUSSION

Button batteries are essential power sources for many household products, and 20-mm lithium batteries provide unique advantages of high energy density, longer shelf and battery life, thin form factor, resistance to cold, and greater voltage and capacitance compared with other button batteries; however, button batteries lodged in the esophagus cause severe tissue damage in just 2 hours, with delayed complications such as esophageal perforation, tracheoesophageal fistulas, exsanguination after fistulization into a major blood vessel, esophageal strictures, vocal cord paralysis from recurrent laryngeal nerve damage, tracheal stenosis or tracheomalacia, aspiration pneumonia, empyema, lung abscess, and spondylodiscitis. Thirteen deaths have been reported to date.[1,5–12] In the past decade, 92% of identified batteries that were implicated in serious or fatal cases were 20-mm-diameter lithium coin cells.[1]

When lodged in the esophagus, an ingested button battery is a much more serious hazard than the more commonly ingested coin. Even the smallest button batteries in the nose, ear, or vagina also cause tissue necrosis.[13–15] In contrast, batteries that pass into the stomach usually run a benign course and are left to pass through the rest of the gut spontaneously.

Three factors have been implicated in battery-induced tissue injuries: leakage of an alkaline electrolyte, pressure necrosis, and generation of an external current that causes electrolysis of tissue fluids, generating hydroxide at the battery's negative pole.[16–20] The last mechanism—generation of hydroxide through electrolysis—is now appreciated as the most important mechanism. Lithium cells do not contain an alkaline electrolyte but rather an organic electrolyte that is only mildly irritating, so leakage does not cause serious complications; however, because 20-mm lithium cells have twice the voltage compared with other button batteries and a higher capacitance, they generate more current and produce more hydroxide. The 20-mm diameter of the most common lithium cell contributes to the problem, because these large cells readily lodge in the esophagus. As a result, the hydroxide generated is focused on a single area of contact, causing more damage than would occur if the battery were moving freely through the gastrointestinal tract.

In children who are younger than 6 years, 12.6% of those who ingest a 20- to 25-mm button battery will experience serious complications or death.[1] Given the limited efficacy of therapeutic modalities for reversing damage that is caused by lodged button cells, the most effective management strategy is prevention. Extrapolating from ingestion scenario, battery source, and intended use data from the NBIH, we have developed prevention recommendations for distribution to parents, patients, and consumers (www.poison.org/battery/tips.asp). These tips evolve from the preventable behaviors identified in this analysis. Preventing ingestions by children focuses on checking and securing (taping) the battery compartment of all household products, storing batteries out of a child's reach and sight (including batteries to be recycled), never leaving batteries sitting out loose, and not allowing children to play with batteries. Parents should be instructed to be especially cautious with 20-mm lithium cells, recognized by their common imprint codes CR2032 (or BR or DL prefix), CR2025, or CR2016. (The "CR" prefix refers to the lithium manganese dioxide chemistry, the "20" to the 20-mm diameter, and the final 2 digits to the battery height in tenths of a millimeter [eg, CR2032 is 3.2 mm high]). These cells can also be recognized because they are bracketed in diameter by a penny (19 mm) and a nickel (21 mm). Prevention tips for older youth and adults should focus on avoiding battery–pill confusion, playing with batteries or "holding" them in the

mouth, storing batteries near pills or in pill bottles, leaving batteries loose on bedside tables or in pockets or a purse, or storing batteries where they might be mistaken for or swallowed with food. Should prevention fail, parents, patients, and health professionals can obtain treatment guidance 24/7 from the nurses, pharmacists, and physicians at the NBIH (202-625-3333). A current treatment guideline can be found at www.poison.org/battery/guideline.asp.[1]

Because 61.8% of batteries that were ingested by young children were obtained from products (rather than loose), changes that have the potential to eliminate more than half of all serious battery ingestion cases and deaths could be implemented by product manufacturers. We urge all manufacturers of button battery–powered products to secure the battery compartment so that it cannot be opened by a child and will not open spontaneously when the product is dropped. Manufacturers should be especially attentive to the need to secure the battery compartment of any consumer product that contains a ≥20-mm lithium cell, regardless of whether the product is intended for use by a child. The popular belief that only toys need to be safe for children is ill-construed. Children use or have access to many household products. All battery-powered products, especially those with a ≥20-mm-diameter battery, should require a tool, such as a screwdriver, for access to the battery compartment. Because remote controls (eg, television, garage door, music player, DVD player, and keyless entry remotes) were implicated in 37.7% of ingestions of 20-mm lithium cells by young children and 65.2% of those batteries were obtained from the remote by the child, remote control devices would be an ideal first focus for product redesign; however, all household products eventually require a secure battery compartment, accessible only with a tool or through a child-resistant locking mechanism (eg, twist lock, push and turn mechanism).

Although less of an issue compared with product closures, battery packaging was implicated in 8.2% of ingestions by children who were younger than 6 years. Child-resistant unit-of-use battery packaging such as secure blister packs (without a perforated backing) or specialized adult-friendly, child-resistant packaging should be used for direct-to-consumer sales of button batteries, especially for those that are ≥20 mm in diameter.

Battery and product packages and product instructions offer an opportunity to educate and warn. Industry-wide standards should mandate warnings regarding the serious complications, including death, that may follow the ingestion of batteries and should advise consumers to obtain urgent medical attention if a battery is swallowed or placed in the nose or ear. At a minimum, these warnings should be required for ≥20 mm button batteries. Although the ingestion hazard is less for smaller cells, it may also be advisable to include warnings for batteries as small as 11 mm.

There are some limitations to this study. The NBIH ingestion scenario data were gathered during telephone consultations with patients, parents, or treating health professionals rather than through direct observation, and no methods were in place to verify the caller's report. The feasibility and cost–benefit ratio of the proposed safety interventions were not investigated. The NBIH, as a resource for specialized expertise, may disproportionately capture more serious cases; however, this bias should strengthen the results by focusing the analysis on more hazardous ingestions, which are those that we strive most to prevent.

## CONCLUSIONS

In recent years, button batteries, especially 20-mm lithium cells, have emerged as a serious and potentially lethal ingestion hazard. As use of these cells in household products increases, the incidence of devastating injury from battery ingestions is also rising. Thus, prevention of battery ingestions, especially of ingestions of large-diameter button batteries, is essential. Parents and child care providers must be informed of the hazard and of appropriate actions to take to prevent ingestions. Product manufacturers need to redesign battery-powered household products to secure the battery compartment, for example by requiring a readily available tool, such as a screwdriver, to open the compartment.

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***US Birth Rate Declines in Setting of Recession (with One Exception):*** *The United States birth rate dropped 2% in 2008 according to an article in* The New York Times *(Associated Press, April 6, 2010) and the most likely explanation is the current recession, combined with a decline in immigration due to the weak job market. Interestingly, the only increase in birth rate (4%) was to women in their 40s who perhaps felt they could not wait for better economic times. The article cites data from a report issued by the Centers for Disease Control and Prevention based on a review of more than 99% of birth certificates in 2008. Preliminary information for the first half of 2009 suggests that the decline continues with birth rate down another 3% overall—largely involving teenagers and women in their 20's and 30's. The biggest declines were seen in Arizona, California, and Florida, all of which have been struggling fiscally as per recent economic metrics. A positive in the birth rate statistics is that the prematurity rate also dropped in 2008 from 12.7 to 12.3 percent.*

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