Background: Methacrylic acid–containing primers used in artificial nail cosmetic products are typically not contained in child-resistant packaging, although they are sold to the general public.

Objective: To analyze the type and severity of childhood poisoning injuries involving methacrylic acid–containing artificial nail primers.

Design: Secondary analysis of 2 national, population-based injury data sets.


Subjects: Children younger than 6 years with injuries associated with exposures to nail primers.

Results: In the National Electronic Injury Surveillance System, there were 769 exposures to nail preparations, 32 (4.2%) of which involved nail primers. Twenty-eight (87.5%) of 32 nail primer exposures involved children younger than 6 years. Of the severe nail primer injuries, 80% involved preschoolers; most of the injuries were dermal burns. In the Toxic Exposure Surveillance System data set, there were 759 methacrylic acid–containing nail product exposures, of which 567 (74.7%) occurred in children younger than 6 years. Of exposures in preschool children, 56 (9.9%) resulted in moderate severity injuries and 3 (0.5%) in “major” injuries; there were no deaths.

Conclusions: Artificial nail primers containing methacrylic acid represent a corrosive hazard to young children and have been associated with severe injuries. New product labeling and packaging regulations and public education measures that recognize this hazard are recommended.


Editor’s Note: Since essentially 100% of adults who use nail cosmetics are women, I wonder if that same preponderance by gender held true for those children exposed in this study. Any bets?

Catherine D. DeAngelis, MD

The artificial nail cosmetics industry in the United States has grown 4% to 5% annually; according to Women’s Wear Daily (March 1, 1996;171:14), revenues in 1995 were approximately $265 million. While some products may be intended for purchase by professional cosmeticians only, many “wholesale beauty supply shops” are open to the public and sell nail care and artificial nail products without restrictions as to the qualifications of the purchaser. Artificial nail application products, including nail primers, are also sold in pharmacies and other cosmetics outlets.

An agent known to be highly corrosive, methacrylic acid, is used in the application of artificial nails. The application of artificial nails requires that the fingernail of the client be cleaned, degreased, and etched to allow increased adherence of the artificial nail. Etching, the final step before attachment of the nail, is usually achieved with methacrylic acid. Once the nail preparation is complete, the artificial nail is built by means of an acrylic monomer solution and a powdered polymer compound. The resulting chemical reaction creates the hard, polyacrylic plastic surface constituting the artificial nail. The process is repeated every few weeks as the natural nail grows out, to give the artificial nail its uniform, sculpted appearance.
METHODS

We analyzed 2 existing population-based data sets documenting the frequency and severity of poisoning injuries in the United States: the National Electronic Injury Surveillance System (NEISS) data set compiled by the Consumer Product Safety Commission (CPSC) and the Toxic Exposure Surveillance System (TESS) compiled by the American Association of Poison Control Centers (AAPCC).

The NEISS data set contains reports of injuries severe enough to require medical attention in emergency departments. It collects current injury data associated with more than 15,000 consumer products from hospital emergency departments across the United States. It consists of a national randomly selected probability sample of approximately 100 hospitals of differing sizes (based on the annual number of emergency visits) and locations, as well as children's hospitals and trauma centers. Data reported in the NEISS data set are weighted according to the probability of hospital selection on the basis of 4 categories of hospital size. Variables in the data set include patient's age and sex, product category, injury diagnosis, body part affected, accident locale, disposition of the case, and injury severity. Severity is scaled as follows: 1, mild injury to small area; 2, nonhospitalized poisoning; 3 to 5, moderate injury to larger area; 6 and 7, hospitalized poisoning; and 8, death. A brief narrative report is sometimes available.

For the purposes of this study, only injury cases classified as associated with “nail preparations” (CPSC code 2630) or “nail hardeners” (CPSC code 2631) were included. Product types were recategorized to include nail polishes, polish removers, artificial nails, nail primer, nail hardeners or strengtheners, and an “other” category. Injury diagnoses were categorized as ingestion, inhaled irritant, eye irritation or burn, dermal rash or burn, avulsions, foreign body, lacerations, and “other” diagnoses. Site of exposure was recategorized as either “patient’s home” or “other.” Data from years 1991, 1992, and 1993 in the NEISS data set formed the basis of the analysis; unfortunately, the CPSC discontinued collecting nail cosmetics–specific data subsequent to 1993.

The AAPCC's TESS data set contains reports of poisonings telephoned to 67 reporting poison control centers in the United States from all sites, including private residences, health care facilities, schools, and other public places. These poison control centers serve a catchment area containing approximately 83% of the US population. Information extracted from this data set includes patient's age, sex, reason for overdose (intentional or unintentional), product type, dose and route of exposure, time since exposure, signs and symptoms of toxic reactions, treatment, treatment site, observation period, and medical outcome (severity). As with the NEISS data set, we recategorized the “site of caller” variable in the TESS data set as either “home” or “other.” The “route of exposure” variable was coded as ingestion, inhalation, dermal, ocular, combinations of the above, or “other.” Each poisoning exposure recorded by a poison control center is followed up by staff until an adequate disposition of the case has been defined. Outcomes are recorded according to instructions distributed by the AAPCC and include the categories no effect, mild effect, moderate effect, and severe effect. Cases without follow-up are coded by poison control center staffs as “not followed up, judged as nontoxic exposure,” “not followed up, minimal clinical effects possible,” or “unable to follow up, judged as a potentially toxic exposure.” Occasionally cases are coded as “exposure not responsible for the effect” if the patient’s medical condition was clearly from some other cause rather than the putative toxin.

Products containing methacrylic acid were inventoried by means of the Poisindex (Micromedex Corp, Denver, Colo) data retrieval system and categorized as those with methacrylic acid concentrations of 80% to 100% (high-concentration products), those with methacrylic acid concentrations of 70% to 79% (moderate concentration products), and those with unknown concentrations (Table 1). An analysis of injury outcomes was then made comparing high- vs low-concentration products.

Both data sets were analyzed first by means of descriptive statistics. Inferences were made with “outcome” or “severity” used as the dependent variable. Categories of severity in the NEISS data set were collapsed so that scores of 0 to 3 were regrouped as “no effect/minor” and scores of 4 to 7 as “moderate/major.”

For the AAPCC data set only, a “product hazard score” was also calculated by the method previously described by Litovitz and Manoguerra. Briefly, this score uses poisoning data to derive an assessment of a product’s “hazard,” dependent not only on its toxic potency but also on such characteristics as the product’s accessibility, packaging, and total dose in the container. The hazard score was calculated for children younger than 6 years by summing the outcome’s major toxicity (M) and death (D) and dividing by the total (T) poisonings: (M+D)/T. The hazard score calculated for methacrylic acid–containing nail products was then compared with previously reported hazard scores for other products calculated from the TESS data set for the years 1985 through 1989.

Categorical variables were further analyzed for inferences about group differences by means of the $\chi^2$ statistic. Statistical significance was inferred by an alpha level of .05 or less. All statistical analyses were performed on a PowerMac microcomputer with SAS software.

RESULTS

At the Massachusetts Poison Center, Boston, we became aware of several children who had suffered oral and/or dermal burns after unintentional exposures to artificial nail primers containing methacrylic acid. These products were not contained in child-resistant packaging, and parents were unaware that the products posed a threat to their children. Moreover, information in the computerized database used by our staff did not define nail primers as a corrosive hazard but merely as a strong irritant. The purpose of the current study was to investigate further the frequency and severity of childhood exposures to nail primers containing methacrylic acid and to study the hazard they might represent to children.

Table 1 shows representative nail primer cosmetics containing methacrylic acid and the concentration in each.
Of the 769 emergency department visits for exposures to nail products recorded in the NEISS data set during the 3 years under study, 421 (54.7%) of which involved children younger than 6 years. Of the total 769 nail product injuries, 32 incidents (4.2%) involved artificial nail primers: 6 ingestions (19%), 2 eye-only exposures (6%), 19 dermal-only exposures (59%), and 2 “other” (6%). There were also 2 ocular/dermal combination exposures (6%) and 1 ingestion/ocular combination (3%). Table 2 compares the age, circumstances, and severity of emergency department patients exposed to nail primers with those exposed to all other types of nail products. Most of the incidents involving nail primers were in young children: 28 (87.5%) of these exposures involved children 1 to 3 years old. Twenty-five (89%) of the 28 pediatric exposures occurred in the child’s own home.

Of the 737 “other nail product” exposures recorded, there were 120 (16.3%) in which the resulting injuries were rated by emergency department staff as of moderate to major severity. However, injuries from nail primers were more often rated as severe; 20 (62.5%) of the 32 injuries associated with nail primers were rated as moderate to major ($\chi^2=43.8; P<.001$). Of the 21 exposures to nail primers resulting in dermal burns, 16 (76%) of the injuries were rated as moderate to severe.

According to the manufacturer, none of the products is currently packaged in a child-resistant container, although some have external child-resistant packaging that can be discarded once the product has been purchased and opened. What remains is a small bottle containing the primer with a simple screw-type top (Figure 1).

### NAIL PRODUCT EXPOSURES: EMERGENCY DEPARTMENT VISITS

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### METHACRYLIC ACID–CONTAINING NAIL PRODUCTS

There were 71,033 exposures to cosmetics reported to TESS by participating AAPCC poison control centers from 1993 through 1995. There were 759 exposures to methacrylic acid–containing nail products reported to TESS, of which 645 (84.9%) occurred in the home and 567 (74.7%) were among children younger than 6 years. Figure 2 shows the distribution of exposures by age and exposure site: 2-year-olds were at highest risk of unintentional exposures to these products. Whereas in adolescents and adults, dermal-only exposures alone accounted for 92 (57.1%) of 161 reports to poison control centers, ingestions or mixed dermal/ingestion exposures accounted for 89% (505/567) of the reports concerning children younger than 6 years.

Figure 3 shows the severity of the injuries sustained as a result of exposure to these products. Of the 567 preschoolers who were exposed to methacrylic acid–containing products, 56 (9.9%) suffered clinical outcomes coded as of “moderate” severity and 3 (0.5%) suffered “major” injury. Fifty (84%) of these 59 children with severe injuries had predominantly dermal, oral, and/or eye burns. Products were then categorized by their concentration of methacrylic acid into the following categories: moderately concentrated (70%-80% methacrylic acid) and highly concentrated (>80% methacrylic acid). There was no statistical association between injury outcome severity and product acid concentration.

The raw hazard score calculated for preschoolers suffering major injuries from methacrylic acid–containing nail products was 0.0053. The score was then normal-
This study highlights the hazard to young children posed by artificial nail primer solutions that contain methacrylic acid. Since this caustic chemical appears to be the best one available to prepare fingernails for optimal adhesion of the artificial ones, most commercial artificial nail primers contain methacrylic acid. Methacrylic acid (chemical formula, CH$_2$5C[CH$_3$]COOH) is also known as a-methyl acrylic acid; its CAS registry number is 79-41-4. This chemical is a known corrosive; a 10% solution has a pH of 2.4 and a sharp, acrid odor. Currently the Poisindex reference used by most US poison control centers does not identify the potential of methacrylic acid–containing nail primer products for caustic injury. However, the Methacrylic Acid Task Force of the Methacrylate Producers Association states in its safe-handling manual prepared for industrial purposes, Methacrylic acid is a liquid at room temperature and pressure. When inhaled or swallowed even in low concentration, it can burn mucous membranes. Contact with liquid will cause severe burns of the eye or skin.

Exposures to nail primers are uncommon in the NEISS data set, accounting for only 4% of patients coming to the emergency department with injuries from nail cosmetics. However, when patients exposed to artificial nail primers did come to the emergency department, they were usually young children suffering severe dermal burns. These products were more often associated with severe injuries than were unintentional exposures to all other types of nail preparations. We also found that incidents involving the nail primers usually occurred in the child’s own home, rather than in beauty salons.

Similarly, 75% of the more than 250 calls placed to US poison control centers annually concerning expo-

**Table 2. Nail Primer Injuries Seen in a Sample of US Emergency Departments Compared With Injuries From All Other Nail Products***

<table>
<thead>
<tr>
<th>Variable</th>
<th>Nail Primer Product (n=32)</th>
<th>Other Nail Product (n=737)</th>
<th>$\chi^2$</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &lt;3 y</td>
<td>87.5</td>
<td>53</td>
<td>16.13</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Severe injury (score 4-6)</td>
<td>62.5</td>
<td>16.3</td>
<td>43.8</td>
<td>.001</td>
</tr>
<tr>
<td>Severe injury; dermal-only exposures</td>
<td>76.2</td>
<td>43.8</td>
<td>6.43</td>
<td>.01</td>
</tr>
</tbody>
</table>

ures to methacrylic acid–containing nail primers involved children younger than 6 years who had ingested the products or splashed the liquid contents on their skin or eyes. Follow-up of these poison control center calls showed that almost 10% of the children suffered injuries of moderate or major severity related to the exposure. As was the case in the NEISS data, the circumstances of the exposure again implicated the child’s own home as the site of the incident.

The results of this study should be interpreted with caution. The data sets overlapped by 1 year and cannot be easily linked. Thus, it is likely that some of the 354 calls in the 1993 TESS data set concerning nail primer exposures included some of the same incidents reported in the subset of 8 emergency department visits in the 1993 NEISS data set. These few redundant patients would not materially change the results of our analysis. The NEISS data set does not distinguish ingredients or brand names, such that entries listed as “nail primers” were assumed to contain methacrylic acid but perhaps did not. Nevertheless, the high frequency of caustic burns involving the products involved in incidents reported in the NEISS data set suggests that most contained the acid. Many of the telephoned exposures in the AAPCC data set were reported by generic chemical or product type only, rather than by specific brand name, and many such telephoned reports are not followed up, so that patient outcome was sometimes unknown. Thus, only an incomplete analysis relating a product’s methacrylic acid concentration to the severity of the injury produced was possible.

Not all nail products containing methacrylic acid have equal potency. We found a range of concentrations from 70% to 100% methacrylic acid. Indeed, a handful of products labeled “nail primer” may not contain methacrylic acid at all. We did not find a difference in the injury severity when we compared exposures to nail primers containing 70% to 80% methacrylic acid with those containing higher concentrations of the acid. The lack of an association between methacrylic acid concentration and severity of injury from the exposure only reinforces our opinion that methacrylic acid is a potent caustic agent. It seems clear that those brands containing more than 70% methacrylic acid pose an important hazard to young children; whether lower concentrations would hold the same threat remains unknown. It seems reasonable to speculate that there might exist a concentration of methacrylic acid (lower than 70%) that affords equal efficacy in terms of etching the nail while representing a lessened caustic threat from an unintentional childhood exposure.

The hazard score we calculated for these nail products was high, reflecting not only the corrosive potency of methacrylic acid but also the fact that these products were accessible to young children and not uniformly found in child-resistant packages. The hazard score for methacrylic acid–containing nail products was much higher than that for other common nonpharmaceutical childhood exposures, such as plants (hazard score, 0.1), and was comparable with the hazard scores of kerosene and ethanol (Table 3). The relatively high hazard score calculated for methacrylic acid nail primers identifies them as consumer products worthy of both public health and manufacturer efforts to increase their safety when they are used where children are likely to gain access to them.

Why are we finding cause for concern now? Changes in the cosmetics industry may provide some explanations, or at least grounds for speculation. Until recently methacrylic acid–containing nail products were largely restricted to professional cosmeticians who used them in salons. The likelihood that children would be exposed to the product under these circumstances of use was minimal. However, professional nail applications are expensive, and there has been a trend toward home use of more inexpensive artificial nail products during the past 5 to 10 years. Likewise, the industry has become more encouraging of home application of the nails to achieve “beautician-quality” results. We speculate that the recent changes in marketing strategy for such artificial nail products, without a concomitant review of packaging safety, have led to the present hazardous situation for young children in the home.

Currently, artificial nail primers are contained in screw-top, small, amber-colored bottles usually containing about 1 oz or less of the viscous, acrid, foul-smelling liquid. The caps are not child resistant. Some manufacturers, recognizing the hazard, have placed the bottles within plastic containers that do have child-resistant caps. However, the consumer can simply remove and discard such a container, resulting in an unsafe product in the home. Moreover, none of the bottles or containers had adequate consumer warnings. Such labeling should convey not only the hazard of the contents, but also the first aid to render in the event of an unintentional exposure.

Cosmetics generally are regulated by 2 governmental agencies, the Food and Drug Administration (FDA) and the CPSC. The FDA monitors the safety of cosmetics and can promulgate regulations related to ingredients, packaging, and labeling. Contaminated or untested cosmetics, or those associated with unacceptably high rates of adverse reactions, can be removed from the marketplace by the FDA. The FDA does not have the

### Table 3. Representative Hazard Factor Scores for Methacrylic Acid–Containing Nail Primers and Other Household Products*

<table>
<thead>
<tr>
<th>Product</th>
<th>Hazard Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rodenticides</td>
<td>0.1</td>
</tr>
<tr>
<td>Matches</td>
<td>0.1</td>
</tr>
<tr>
<td>Plants</td>
<td>0.1</td>
</tr>
<tr>
<td>All cosmetics</td>
<td>0.2</td>
</tr>
<tr>
<td>Paints</td>
<td>0.3</td>
</tr>
<tr>
<td>Moth repellents</td>
<td>0.5</td>
</tr>
<tr>
<td>Polishes/waxes</td>
<td>0.5</td>
</tr>
<tr>
<td>Tobacco products</td>
<td>0.6</td>
</tr>
<tr>
<td>Kerosene</td>
<td>7.9</td>
</tr>
<tr>
<td>Ethanol-containing beverages</td>
<td>8.0</td>
</tr>
<tr>
<td>Nail primers</td>
<td><strong>8.6</strong></td>
</tr>
<tr>
<td>Oven cleaners</td>
<td>28.8</td>
</tr>
<tr>
<td>Acetic acid drain cleaners</td>
<td>46.5</td>
</tr>
</tbody>
</table>

*See text for the method used to calculate the hazard factor score. Comparative scores for household products other than nail primers are taken from Litovitz and Manoguerra. 4(p1002-1003)
authority to regulate unintended practices involving cosmetics. Thus, it is not mandated to act on reports of injuries related to ingestion of a cosmetic, if the cosmetic was not intended by the manufacturer to be used in this manner. Such safety concerns would be referred to the CPSC for possible actions regarding packaging design and whether child-resistant closures might be advisable.

We believe it is important that the FDA and the CPSC collaborate with the cosmetics industry in revisiting the regulation of artificial nail primers, to improve their safety and better educate consumers and cosmeticians about the potential hazards they represent and the precautions to be taken to ensure their safe use. We also urge that the FDA and CPSC encourage all manufacturers to consider re-engineering the current packaging and labeling of these products to reduce the risk of inadvertent childhood exposures. We strongly advocate that the formulation of nail primers be revised to include an alternative safer chemical, if one exists, or at least a ceiling on the concentration of methacrylic acid in products intended for home use. Further testing may be necessary to determine what concentration of methacrylic acid presents the least corrosive effect on tissues but maintains the greatest efficacy in the preparation of nails for cosmetics.

On the basis of the data presented here, we make the following recommendations:

1. Cosmetic manufacturers should alert consumers to the potential hazard of artificial nail primer products when young children are in the vicinity of their use.
2. Revised product labeling should adequately warn consumers of the caustic hazard of artificial nail primers and of the appropriate first aid to take in the event of an unintentional exposure.
3. Nail primer products should be repackaged to include features that present barriers to access by young children.
4. Cosmetology research should be directed toward less toxic chemical alternatives to methacrylic acid as the priming substance, or at least toward the use of formulations that contain less concentrated solutions of methacrylic acid.

**CONCLUSIONS**

Artificial nail primers that contain methacrylic acid represent a corrosive hazard to young children. Severe dermal burns were present in 14 preschool children among the 32 patients with nail primer exposures seen in a sample of injured patients who came to US emergency departments in 1991 through 1993. Among 567 calls to US poison control centers concerning childhood exposures to methacrylic acid–containing nail products during 1993 through 1995, 56 children (9.8%) suffered moderate injuries and 3 (0.53%) suffered major injuries. New product labeling and product packaging regulations for nail primers are recommended to prevent this injury, along with public education measures alerting consumers to the corrosive hazard that methacrylic acid–containing nail primers represent.

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We acknowledge the NEISS coding nosologists from each participating hospital, who retrieved the information necessary to the investigation of this injury; and the assistance of the CPSC in making the coded data available to us. Our thanks also to Toby Litovitz, MD, and the staff of the central office of the American Association of Poison Control Centers for access to the TESS data. We also acknowledge with appreciation the specialists in poison information throughout the United States, whose efforts to document and code toxic exposures form the data set that is in part the basis for this report.

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