# Traditional Eye Cosmetics and Cultural Powders as a Source of Lead Exposure

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abstract

**OBJECTIVES:** We aimed to describe the characteristics of traditional eye cosmetics and cultural powders, including the types, lead concentrations, origin, and regional variation in product names, and assess the differences in blood lead levels (BLLs) between product users and non-users.

**METHODS:** We analyzed 220 samples of traditional eye cosmetics and cultural powders collected in New York City between 2013 and 2022 during lead poisoning investigations and store surveys. We compared the BLLs of children who used these products with those of non-users.

**RESULTS:** Lead levels in traditional eye cosmetics *surma* and *kohl* were much higher than levels in *kajal* and other cultural powders. Although the terminologies *surma*, *kohl*, and *kajal* are often used interchangeably, findings suggest regional variations in the product names. The majority of the *surma* in this study were from Pakistan, *kohl* was from Morocco, and *kajal* was from India. The results also show that these products can contribute to elevated BLLs in children.

**CONCLUSIONS:** Our study reveals that traditional eye cosmetics and cultural powders are used among children as young as newborns, and exposure to these products can significantly add to their lead body burden. The study findings also reveal that lead concentrations in these products can vary by product type and product names can vary by region. Public health officials must be cognizant of these unique variations and use culturally appropriate terminologies for these types of products because such distinctions can be critical when conducting risk assessments, risk communication, and risk reduction activities.

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Although there has been a marked decline in the overall rate of lead poisoning in New York City (NYC) over the past several decades, which is due in large part to successful policies aimed at controlling sources of lead in the environment, certain immigrant communities continue to be at an increased risk for lead exposure.[1–2] The NYC Department of Health and Mental Hygiene's (DOHMH) data reveal that children with mothers born in Pakistan, Afghanistan, and Nepal had rates of elevated blood lead levels (BLLs) up to 4 times greater than the citywide rate. Similarly, children with mothers born in North and West African countries, such as Morocco and Côte d'Ivoire, were also among those with an average rate of elevated BLL exceeding the citywide rate. For these immigrant groups, the use of certain lead-containing consumer products, including traditional spices, health remedies, and cookware has been found to be associated with elevated BLLs.[3–7]

Traditional eye cosmetics known as *surma*, *kohl*, or *kajal* have also been found to contain hazardous levels of lead. These galena- or soot-based products are available in the form of black powders or pastes and are typically applied around the eyes. They are widely used in Asia, the Middle East, many areas of Africa, and increasingly in Europe because of recent immigration patterns.[8] Despite being banned in the United States, South Asian, Middle Eastern, and North and West African immigrants frequently purchase these products abroad and hand-carry them into NYC.[3] Among these immigrant communities, *surma*, *kohl*, and *kajal* are not only used as makeup but also serve diverse cultural purposes, including warding off the "evil eye," improving eye health, or adhering to religious traditions. For this reason, they are commonly used on children as young as newborns, and this practice persists throughout their lives. Similarly, religious powders, such as *sindoor* and *bibhuti*, which are used among South Asian immigrants, may contain high levels of lead.[9,10] *Sindoor*, a traditional vermillion red- or orange-red-colored powder, may be used by married Hindu women as a symbol of marriage or used during prayers.[9] Manufacturers may add lead tetroxide to *sindoor* to give it its distinctive color. These cultural powders can be used by adults and young children, who are particularly susceptible to lead exposure given their higher frequency of hand-to-mouth activity.[11]

Although the authors of previous studies have recognized the potential for lead exposures associated with these products, research documenting their availability in the United States is limited and often based on case studies.[9,10,12–16] Studies that assess lead content in these products along with the BLLs among users in the United States are rare. With this article, we address this gap by examining the characteristics of a variety of traditional eye cosmetics and cultural powders that the DOHMH analyzed during a 10-year period as part of lead poisoning investigations and store surveys. We aim to explore patterns in lead concentrations by product type and possible variances in product names based on the purchase country and describe characteristics of children who used these products, compared with non-users. Although these products pose a risk under any name, it is critical to understand how nomenclature varies in different communities to identify and reduce the risk of exposure. Because the sale of some of these products is already banned in the United States and they are not marketed to children, they may be overlooked as potential sources of lead exposure among children residing in the United States. Understanding the availability, lead concentrations, and the effect on BLLs of these products, which are widely used, even in countries in which such products are banned, is crucial for reducing exposure to lead among immigrant communities, not only in NYC but also around the world.

## METHODS

### Sample Collection

The DOHMH conducts routine blood lead surveillance of children and adults with BLLs at or above the Centers for Disease Control and Prevention's blood lead reference level. Before June 2019, Local Law 1 of 2004 required the DOHMH to conduct environmental investigations for NYC children with elevated blood lead levels of ≥15 ug/dL. Since then, the DOHMH has been conducting environmental investigations for all children with elevated blood lead levels ≥5 ug/dL, and starting in March 2022, the DOHMH has been providing these services to all children with a confirmed blood lead level of 3.5 ug/dL or greater. During these investigations, the DOHMH collects samples of suspected lead-containing products reportedly placed in the mouth or ingested by the lead-poisoned individual.[4] Investigators also routinely visit NYC stores to check for the availability of hazardous consumer products and purchase samples for lead testing. Samples are analyzed for lead by an accredited laboratory using the Environmental Protection Agency Inductively Coupled Plasma Mass Spectrometry Method SW6020 or Atomic Absorption Method SW7420 after acid digestion via Environmental Protection Agency Method 3050. Laboratory results with product-related information, such as product name, usage, and purchase source, are documented for all consumer products collected and tested during lead poisoning case investigations and store surveys in a proprietary Structured Query Language Server database. These data are also accessible through NYC Open Data.[3] This public health activity is not subject to review by the DOHMH Institutional Review Board because the scope is limited to public health practice, and all activities are authorized and conducted by DOHMH, a public health authority.

## Study Sample

### *Consumer Products*

We analyzed traditional eye cosmetics and cultural powders collected between 2013 and 2022. These products were categorized into the following 6 groups on the basis of product labels or information provided by families: *surma, kohl, kajal*, unlabeled eyeliner, *sindoor/kumkum,* and other cultural powders. The latter category included *gulal, holi, tika, bibhuti*, and *tabiz* powders. We differentiated between *surma, kohl,* and *kajal* because of variations in their traditional preparations and expected differences in lead content.[12] We also explored whether the product names varied by the country of purchase.

### *Participants*

To investigate the association between product use and BLLs, we identified children <18 years of age with elevated BLLs reportedly using these products. We frequency-matched, on the basis of age and maternal country of birth, a control group of children with elevated BLLs who did not use any imported products. We compared incident BLLs for product users and non-users. To exclude the possibility that any observed difference in BLL between the case and control group was due to subjects using other imported products with high lead concentrations, we repeated the analyses without including the children who used other products with lead concentrations of 10 ppm or greater. Given the prevalence of old housing stock in NYC, we assumed that both groups were likely exposed to lead-based paint in the home. We tested the differences in paint inspection outcomes to rule it out as a factor driving the differences in BLLs.

## Statistical Analyses

Descriptive statistics were calculated for all products, as well as separately for products with detectable lead levels. For each product category, we calculated the percentage of products exceeding the US Food and Drug Administration (FDA) reference limit of 10 ppm for lead in externally applied cosmetics.[17] We also calculated descriptive statistics for demographic characteristics, BLLs, and home inspection outcomes of children whose families reported use of traditional eye cosmetics and cultural powders and for the control group. To assess the differences between these groups, we used the $\chi^2$ test and Mann–Whitney *U* test. All analyses were conducted by using IBM SPSS version 28.

# RESULTS

## Lead Concentration by Product Type

A total of 220 samples of traditional eye cosmetics and cultural powders were collected during lead poisoning investigations involving 110 children, 10 adults, and 18 store surveys (Table 1). The products were categorized as follows: 37% were classified as *surma* ($n$ = 81), 24% were classified as *sindoor/kumkum* ($n$ = 53), 17% were classified as *kajal* ($n$ = 38), and 5% were classified as *kohl* ($n$ = 11). Additionally, 12% were classified as other cultural powders, including *gulal, holi, tika, bibhuti*, and *tabiz* powder ($n$ = 26). A total of 5% of the samples were unlabeled eyeliners ($n$ = 11). The highest lead concentrations were observed for samples of *surma* (980 000 ppm) and *kohl* (850 000 ppm), with median concentrations of 730 000 ppm (73%) lead. All samples of *surma* had detectable levels of lead (geometric mean [GM] = 289 137 ppm; geometric SD [GSD] = 18.7 ppm), and 96% exceeded the United States FDA reference limit of 10 ppm. Similarly, 91% of the *kohl* samples had detectable levels of lead (GM = 74 650 ppm; GSD = 50.4 ppm), and all exceeded the reference limit. In contrast, samples of *kajal* had lower lead concentrations than *surma* and *kohl* (GM = 4.2 ppm;

**TABLE 1** Descriptive Statistics of Traditional Eye Cosmetics and Cultural Powders Analyzed for Lead, NYC 2013–2022

| Type of Product | No. of Samples (% of Total) | Lead Concentration Percentiles, ppm: 25th | Median | 75th | 90th | Maximum | Geometric Mean (Geometric Standard Deviation) of Samples With Detectable Lead, ppm | | Percentage[a] of Samples With Lead Concentration Greater Than Reference: Above Detection Limit, % | >10 ppm, % |
|---|---|---|---|---|---|---|---|---|---|---|
| *Surma* | 81 (37) | 470 000 | 730 000 | 850 000 | 910 000 | 980 000 | 289 137 | (18.7) | 100% | 96% |
| *Kohl* | 11 (5) | 2945 | 730 000 | 820 000 | 830 000 | 850 000 | 74 650 | (50.4) | 91% | 91% |
| *Sindoor, kumkum* | 53 (24) | 0.3 | 3.1 | 10.0 | 185 | 870 000 | 10.1 | (25.3) | 79% | 25% |
| Other cultural powders (*gulal, holi, tika, bibhuti, tabiz* powder) | 26 (12) | 0.3 | 3.1 | 5.0 | 190 | 760 | 6.4 | (9.3) | 77% | 20% |
| Eyeliner (unknown type) | 11 (5) | ND | ND | 0.2 | 7.0 | 36 | 4.9 | (8.9) | 27% | 9% |
| *Kajal* | 38 (17) | ND | ND | 3.2 | 6.2 | 160 | 4.2 | (5.2) | 42% | 5% |
| Total all types | 220 (100) | 0.4 | 9.6 | 635 000 | 850 000 | 980 000 | 1836 | (389.2) | 78% | 49% |

ND, non-detectable.
[a] Represents row percentage.

GSD = 5.2 ppm), with a median lead concentration of nondetect and only 5% exceeding the reference limit. Lead concentrations in unlabeled eyeliners were similar to those of *kajal* (GM = 4.9 ppm; GSD = 8.9 ppm), and 9% exceeded the reference limit. Although the maximum lead concentration for *sindoor/kumkum* was 870 000 ppm, the overall lead concentrations of these products were lower than those in samples of *surma* and *kohl* (GM = 10.1 ppm; GSD = 25.3 ppm). Lead concentrations in the other cultural powders were also lower than those in samples of *surma* and *kohl* (GM = 6.4 ppm; GSD = 9.3 ppm). Only 20% to 25% of the *sindoor/kumkum* and other cultural powders exceeded permissible limits, with median lead concentrations of ~3 ppm.

## Product Types and Countries of Purchase

The purchase country was reported for most (97%) of the samples (Table 2). Almost half of the products (46%) were purchased in the United States, with >80% of them collected during store surveys. The remaining samples were purchased in South Asian countries (39%), followed by countries in North and West Africa (6%) and Central Asia and the Middle East (6%). Although sales of *surma, kohl, and kajal* are prohibited in the United States,[18] 12% of *surma*, 18% of *kohl*, and 63% of kajal samples were purchased in the United States.

Although the terminologies *surma, kohl*, and *kajal* are often used interchangeably, Table 2 reveals regional variations in the reported product names. For instance, the majority of the *surma* samples were from South Asia (60%), predominantly from Pakistan (51%), followed by the Middle East (17%), specifically Saudi Arabia (16%). In contrast, more than half (55%) of the *kohl* samples were from North or West Africa, predominantly Morocco (18%), followed by South Asia (27%), particularly Pakistan (18%). *Kajal* was typically from South Asia (29%), predominantly from India (16%). Although >70% of the cultural powders *sindoor/kumkum* were purchased in the United States, those purchased abroad were mostly from South Asia (28%), most often from Bangladesh (13%) and India (11%). Similarly, 85% of the other cultural powders were purchased in the United States, whereas India (8%) and Nepal (4%) were the most frequently reported countries of purchase for those obtained abroad.

## Characteristics of Children and Their BLLs

In this study, 110 children with elevated BLLs reported using traditional eye cosmetics and cultural powders. In

**TABLE 2** Types of Traditional Eye Cosmetics and Cultural Powders by Purchase Country, NYC 2013–2022

| | | Eye Cosmetics | | | Cultural Powders | |
|---|---|---|---|---|---|---|
| Country of Purchase | All Products ($n$ = 220) | *Surma* ($n$ = 81) | *Kohl* ($n$ = 11) | *Kajal* ($n$ = 38) | *Sindoor/KumKum* ($n$ = 53) | Other Cultural Powders* ($n$ = 26) |
| United States | 46% | 12% | 18% | 63% | 72% | 85% |
| Store surveys | 37% | 6% | 18% | 55% | 64% | 73% |
| Case investigations | 9% | 6% | 0% | 8% | 8% | 12% |
| South Asia | 39% | 60% | 27% | 29% | 28% | 12% |
| Pakistan | 21% | 51% | 18% | 5% | 0% | 0% |
| India | 8% | 5% | 0% | 16% | 11% | 8% |
| Bangladesh | 5% | 1% | 0% | 5% | 13% | 0% |
| Nepal | 2% | 0% | 0% | 3% | 2% | 4% |
| Afghanistan | 2% | 4% | 9% | 0% | 0% | 0% |
| Sri Lanka | 0% | 0% | 0% | 0% | 2% | 0% |
| North and West Africa | 6% | 5% | 55% | 3% | 0% | 0% |
| Morocco | 2% | 2% | 18% | 0% | 0% | 0% |
| Tunisia | 0% | 0% | 9% | 0% | 0% | 0% |
| Ghana | 1% | 1% | 9% | 3% | 0% | 0% |
| Gambia | 0% | 1% | 0% | 0% | 0% | 0% |
| Nigeria | 0% | 0% | 9% | 0% | 0% | 0% |
| Niger | 0% | 0% | 0% | 0% | 0% | 0% |
| Burkina Faso | 1% | 0% | 9% | 0% | 0% | 0% |
| Central Asia and Middle East | 6% | 17% | 0% | 0% | 0% | 0% |
| Saudi Arabia | 6% | 16% | 0% | 0% | 0% | 0% |
| Tajikistan | 0% | 1% | 0% | 0% | 0% | 0% |
| Unknown or not stated | 3% | 5% | 0% | 5% | 0% | 4% |
| Total | 100% | 100% | 100% | 100% | 100% | 100% |

The country of purchase is shown for all samples with detectable and non-detectable lead. Eyeliners of unknown type were excluded from the table because of small sample size and relatively infrequent findings of samples with detectable lead. They are included in the total of all products.
* Includes, for example, *gulal*, *holi*, *tika*, *bibhuti*, and *tabiz* powders.

**TABLE 3** Comparison of Demographics and Blood Lead Levels Among Children Who Used Traditional Eye Cosmetics and Cultural Powders (Including and Excluding, Children Who Used Other Products With a Pb Concentration of 10 ppm or Greater) to the Matched Control Group of Children

| Characteristic | Children With EBLL Who Used Products,[a] *n* (%) (*N* = 110) | Children With EBLL Who Did Not Use Products, *n* (%) (*N* = 150) | $\chi^2$/Mann–Whitney *U* Test, *P* (A Versus B) | Children With EBLL Who Used Products Excluding Those Using Other Products With Pb Concentrations of ≥10 ppm, *n* (%) (*N* = 95) | $\chi^2$/Mann–Whitney *U* Test, *P* (C Versus B) |
|---|---|---|---|---|---|
| Sex, *n* (%) | | | | | |
| Male | 49 (45) | 69 (46) | .816 | 41 (43) | .663 |
| Age, mo, median (IQR) | 13.5 (11.0—25.25) | 12.5 (10.75—24.25) | .488 | 13 (11.0—24.0) | .671 |
| <6 | 4 (4) | 10 (7) | | 4 (4) | |
| 6–11 | 28 (25) | 32 (21) | | 24 (25) | |
| 12–23 | 47 (43) | 67 (45) | | 43 (45) | |
| 24–71 | 24 (22) | 34 (23) | | 19 (20) | |
| ≥72 | 7 (6) | 7 (5) | | 5 (5) | |
| BLL, ug/dL, median (IQR) | 12.5 (9.0—18.0) | 8.0 (5.0—16.0) | <.001 | 13.0 (9.0—18.0) | <.001 |
| 5–9 | 30 (27) | 83 (55) | | 25 (26) | |
| 10–14 | 36 (33) | 18 (12) | | 33 (35) | |
| 15–20 | 24 (22) | 28 (19) | | 20 (21) | |
| 20–24 | 9 (8) | 10 (7) | | 8 (8) | |
| ≥25 | 11 (10) | 11 (7) | | 9 (10) | |
| BLL (2019–2022),[b] ug/dL, median (IQR) | 9.0 (6.0—12.0) | 6.0 (5.0—10.0) | .001 | 9 (6.0—12.25) | <.001 |
| Home paint inspection completed | 80 (73) | 105 (70) | .632 | 72 (76) | .324 |
| Lead-based paint identified in home[c] | 47 (59) | 76 (72) | .052 | 45 (63) | .165 |
| US-born (*N*) | 79 (72) | 118 (79) | .203 | 70 (74) | .368 |
| Foreign-born mothers | 109 (99)[d] | 150 (100) | | 94 (99)[d] | |
| South Asia (Pakistan, India, Bangladesh, Nepal, Afghanistan, Sri Lanka) | 95 (86) | 140 (93) | | 82 (86) | |
| North and West Africa (Morocco, Algeria, Ghana, Gambia, Niger) | 8 (7) | 10 (7) | | 6 (6) | |
| Middle East (Oman, Tajikistan) | 2 (2) | 0 (0) | | 2 (2) | |
| Other foreign countries (Mexico, Guyana, Hong Kong, Estonia) | 4 (4) | 0 (0) | | 4 (4) | |

EBLL, Elevated blood lead level.
[a] Sixty-five percent (*N* = 71) were predominantly users of *surma*, whereas 17% (*N* = 19) were users of other eye cosmetics, including *kajal* and *kohl*. Approximately 18% (*N* = 20) were users of religious or cultural powders, including *sindoor* and *kumkum*.
[b] Case group *N* = 48; case group, excluding children using other products with lead concentrations of 10 ppm or greater, *N* = 42; control group *N* = 111.
[c] Percentage of those with inspections completed.
[d] Mother's country of birth was not available for 1 child.

our sample, girls slightly outnumbered boys (55% vs 45%; Table 3). The ages of children ranged from newborns to 17-year-olds, with 72% of children under the age of 2. The median age of the children was 13.5 months. Most of the children were US-born (72%), and almost all of the children (99%) had foreign-born mothers. South Asian mothers accounted for the largest percentage (86%), followed by North and West African (7%) and Middle Eastern (2%). The control group, consisting of children with elevated BLLs who did not report the use of imported products ($n = 150$), had similar demographic characteristics. There were slightly fewer boys (46%) than girls, and their median age was 12.5 months. Approximately 79% were US-born, and 100% had foreign-born mothers. None of these differences were statistically significant compared with children who used products.

The families of children who used traditional eye cosmetic and religious powders most frequently reported that they used them for cosmetic or religious purposes, and the usage was typically reported to be daily. Significant differences in the distribution of BLLs were observed between children who used products and those who did not. The median BLL for children who used products was 12.5 ug/dL (interquartile range [IQR] 9.0–18.0 ug/dL), compared with the median of 8.0 ug/dL (IQR 5.0–16.0 ug/dL) for children who did not. This difference in the BLL distribution was significant ($P < .001$). It remained significant even when the data were limited to the most recent period (2019–2022), during which the intervention BLL was lowered to 5 ug/dL. During this period, children who used products had a median BLL of 9.0 ug/dL (IQR 6.0–12.0 ug/dL), whereas children who did not use these products had a median of 6.0 ug/dL (IQR 5.0–10.0 ug/dl; $P = .001$). The inspection results suggest that these differences were not due to variance in exposure to lead-based paint at home. Children who did not use products were marginally more likely to have lead-based paint in the home than children who did (72% vs 59%, respectively; $P = .052$).

Most children who used traditional eye cosmetics and religious powders also used other imported products, most often imported spices; however, the majority of these products had lead concentrations less than detectable levels. When the analyses were repeated, excluding subjects who, in addition to traditional eye makeup or religious powders, also used other products with lead concentrations of 10 ppm or greater ($n = 15$), the exclusion did not affect BLL distribution among subjects. The difference in the distribution of BLL between the case and control group remained statistically significant ($P <$ .001, Table 3). Even with this exclusion, the case and control group did not significantly differ on other variables.

## DISCUSSION

Traditional eye cosmetics and cultural powders are widely used in South Asia, Africa, the Middle East, and increasingly, in Europe.[8,12] Our study reveals that their use also persists among NYC's immigrant communities, even in children as young as newborns; although the sales of these products are banned in the United States, most individuals hand-carry these products from abroad. One of the main findings of our study was that children who used these products had significantly higher BLLs than children from similar backgrounds who did not use them. This is of significance because it indicates that these products could have a more substantial effect on BLLs than often assumed, especially among children. Although our study does not assess the exact exposure routes (eg, ocular, dermal, or hand-to-mouth) it provides evidence that the lead in these consumer products is bioaccessible and can add to the children's lead body burden.[19]

Our study also found that the lead concentrations varied by product type. This can have implications when conducting risk assessments and risk communication. For instance, although the terminologies *surma, kohl*, and *kajal* are often used interchangeably in the United States, our study reveals that lead concentrations in these products vary. Whereas most of the *surma* and *kohl* samples in this study contained extremely high levels of lead (as high as 73 000 times the US FDA permissible limit), the majority of the *kajal* had lead concentrations lower than the permissible limit.[17] This aligns with previous findings that *surma* and *kohl* are more likely galena (lead sulfide)-based and are typically in the form of a fine powder with great potential for hand-to-mouth exposure.[12] In contrast, *kajal* is a soot-based product, typically with much lower lead concentrations. Less than 25% of the *sindoor/kumkum* and other cultural powders exceeded the permissible limit. Although any level of lead exposure is potentially harmful, when conducting risk assessments, it is important to distinguish between products with extremely high levels of lead versus those with much lower concentrations. Gaining an understanding of the lead concentrations in these types of cultural products can inform risk communication and intervention strategies, in which users are advised to use less hazardous alternatives.

Variation in traditional product names, which is documented in our study, poses challenges for risk communication and interventions. For instance, *surma* was the predominant term for products purchased in South Asia and the Middle East (Pakistan and Saudi Arabia), whereas *kohl* was more commonly used for products purchased in North or West Africa, particularly Morocco. *Kajal* was typically from South Asia, predominantly India. Importantly, the names of similar, potentially hazardous, traditional eye cosmetics are not limited to those described in this study. *Tiro*, for instance, is a lead sulfide-based eyeliner product from Nigeria that is not seen in our dataset.[16] It is important for public health professionals to understand these regional variations and use culturally appropriate terminologies when conducting lead poisoning investigations and risk communication activities. This is necessary because families may not otherwise be able to identify the product they are using as potentially lead-containing. A strategy that could be implemented by risk assessors is to ask general questions, such as "Do you use any products on your or your child's eyes as a cosmetic or for other purposes?" before probing further using specific terminologies.

As contribution from other environmental sources of lead declines because of successful lead poisoning prevention policies, it becomes even more important to identify and control sources of lead exposure to such consumer products. Although we are making inferences from consumer product surveillance in NYC, it is likely that potential lead exposure from such products is pervasive among immigrant communities throughout the United States and abroad. Our findings raise concerns that these types of products continue to be available for sale in various parts of the world, including in the United States, in which sales of *kohl, kajal*, and *surma* are prohibited.[3,4,9,18,20] When the lead exposure risk stems from culturally engrained practices, it may be especially difficult to address. Risk communication can be challenging because, for some users, these products have deep religious significance. Their use may continue despite warnings about the potential for lead exposure if culturally accepted less hazardous alternatives are not available. Consequently, incorporating culturally sensitive strategies when conducting risk communication is recommended. For instance, DOHMH has incorporated risk management guidance, such as washing hands after the use of such products and keeping them away from children, as part of the risk communication messaging to reduce the potential for lead exposure. In NYC, we use a multi-pronged approach that incorporates education and enforcement activities to address lead-containing consumer products.[4] DOHMH enforcement has resulted in the removal of tens of thousands of hazardous consumer products from NYC stores.[21] In addition, DOHMH activities have resulted in the issuance of press releases, consumer advisories, health alerts, import alerts, and national recalls. However, challenges remain with respect to informal distribution because users often obtain these products abroad and bring them into NYC.

Long-term solutions are necessary. It is essential to collectively advocate for reformulating these traditional products because their use is culturally engrained and will persist. An ideal solution would be to eliminate lead as an ingredient during manufacturing and provide a culturally appropriate alternative for these types of products. Simply prohibiting the sale of these products will not be sufficient to reduce lead exposure, as illustrated by the availability of these products in the United States, where they are banned. A global multi-pronged and multistakeholder approach must be taken to eliminate the lead source altogether at the countries of origin. For such changes to occur, there needs to be engagement and dialog between health authorities, manufacturers, and faith-based leaders for a sustainable health-protective solution.

The main limitation of our study is that it is based on the convenience sample of products identified during lead poisoning case investigations. It could be argued that *surma* or *kohl* with lower lead concentrations may exist but were not considered in our study because users' BLLs did not exceed the intervention threshold for investigation. However, this is unlikely because store surveys, independent of blood lead intervention thresholds, support our overall findings. We also did not assess the relative contribution of different potential lead sources to children's BLLs. Many users of traditional eye cosmetics and cultural powders also used other products that may have contributed to their lead exposure. However, not many products used daily by the children had lead concentrations as high as the traditional eye cosmetics, and even when we excluded children who used other products with high lead concentrations, the differences in BLL between case and control groups remained significant. The cases in which traditional eye cosmetics or cultural powders are the sole identified source further suggest that these products can play a significant role in elevating BLLs. Small sample sizes for certain product types, such as *kohl*, are also an important limitation. Our data indicate that *kohl* is more often used in North and West Africa, but it is possible that our own lack of awareness of the term *tiro*, which is used in these areas, resulted in fewer samples of eye cosmetics from these regions.

## CONCLUSIONS

Our study reveals that traditional eye cosmetics and cultural powders are used among children as young as newborns, and exposure to these products can significantly add to their lead body burden. Study findings also reveal that lead concentrations in these products can vary by product type, and product names could vary by region. Public health officials must be cognizant of these unique variations and use culturally appropriate terminologies for these types of products because such distinctions can be critical when conducting risk assessments, risk communication, and risk reduction activities. Because these products continue to be available globally, even in places in which sales are prohibited, long-term multi-stakeholder efforts are needed to reformulate these products in the countries of origin and eliminate lead as an ingredient, thereby ensuring a sustainable and health-protective solution for communities worldwide.

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### ABBREVIATIONS

BLL: blood lead level
DOHMH: Department of Health and Mental Hygiene
FDA: Food and Drug Administration
GM: geometric mean
GSD: geometric standard deviation
IQR: interquartile range
NYC: New York City

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