STATE OF MICHIGAN
DEPARTMENT OF COMMUNITY HEALTH
LANSING

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Dear Healthcare Provider:

The attached information sheet was compiled by the Department of Community Health (DCH) as a result of a request from a pediatric clinic that found elevated serum aluminum levels in two pre-teen children. These children live in Lyon Township in Oakland County, Michigan where an aluminum recycling smelter operates. The children have recently attended Dolsen Elementary School in New Hudson, which is about one-half mile in the predominantly downwind direction from the smelter. The children's parent, concerned that her children might be exposed to excess amounts of aluminum, had her children's pediatrician test for serum aluminum levels. The parent and the clinic have requested information regarding what the implications to health are from these elevated levels and how to proceed. The DCH has prepared a separate information sheet for the public.

The attached is not a medical opinion but a compilation of information, primarily from the ATSDR Toxicological Profile on Aluminum (http://www.atsdr.cdc.gov/toxprofiles/tp22.html), the American Academy of Pediatrics' policy statement on aluminum toxicity in infants and children (http://aappolicy.aappublications.org/cgi/reprint/pediatrics;97/3/413.pdf), and several medical centers' websites (e.g., Beth Israel Deaconess Medical Center, Cleveland Clinic). ATSDR is conducting further review.

Other resources you may consider investigating are:
- Local health department (http://www.malph.org/page.cfm/18/)
- Michigan Department of Community Health Toxics Hotline 1-800-648-6942
- Poison Control Centers 1-800-222-1222
- Agency for Toxic Substances and Disease Registry (http://www.atsdr.cdc.gov/toxfaq.html)
- Centers for Disease Control and Prevention 1-888-246-2675
- American Academy of Pediatrics (http://www.aap.org)
- Pediatric Environmental Health Specialty Units (at http://www.aoec.org)

Thank you for your attention to this matter. If you need further assistance, please do not hesitate to contact me.

Sincerely,

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Evaluating Aluminum Exposure:
Information for Healthcare Providers

Aluminum - Key Points:

- One of the most common elements; found in food, drugs, cookware
- Serum reference range (adult) = 0-40 µg/L (children may be similar)
- 24-hour urine reference range (adult) = less than 36 µg (children may be similar)
- Serum levels greater than 100 µg/L increase risk of aluminum toxicity
- Major toxic endpoints are neurotoxic, skeletal, and pulmonary effects
- Patients with normal renal function can reduce body burden by limiting exposure
- Chelation may be considered for patients with near or greater than 100 µg/L levels

General Information:

Aluminum is the third most common element and the most common metal in the earth's crust. Daily exposure to aluminum is inevitable due to its abundance in nature and its diverse use by man.

Sources of Exposure:

General population –

- Processed foods
- Infant formula
- Drinking water
- Antiperspirants
- Cosmetics
- Analgesics
- Anti-ulceratives
- Antidiarrheals
- Antacids
- Airborne dust particulates

Worker population -

- Primary aluminum smelters (processing ore)
- Secondary aluminum smelters (recycling)
- Production/use of compounds containing aluminum
- Aluminum welding

Special populations at risk of excess exposure:

- Persons living near industrial emission sources or hazardous waste sites
- Patients with chronic kidney failure requiring long-term dialysis or treatment with phosphate binders
- Patients requiring intravenous fluids
- Infants, especially premature infants fed soy-based formula containing high levels of aluminum
- Individuals consuming large quantities of antacids, anti-ulcerative medications, buffered analgesics, antidiarrheal medications, or vitamins and food supplements containing aluminum

Absorption/Metabolism/Excretion:
Aluminum is poorly absorbed following either oral or inhalation exposure and is essentially not absorbed dermally. The absorption of ingested aluminum is influenced by its form and the presence of other substances in the gastrointestinal tract that may significantly enhance (e.g., citrate) or hinder (e.g., silica) absorption. Inhaled fine powders of aluminum metal may deposit in the lung. Unabsorbed aluminum is excreted in the feces. The majority of absorbed aluminum is excreted in the urine.

Laboratory Testing:
Blood tests may be run on plasma or serum, however the reference range (3-10 µg/L) is for serum. Withdraw a 7-ml sample (0.6 ml minimum). Use a royal blue-stopper or a red-stopper tube, dependent on blood compartment to be tested. Analyze via atomic absorption spectrometry (AAS).

When using urine as a biomarker for aluminum, it is recommended to obtain a 24-hour sample rather than a random sample, due to the diurnal pattern of elimination. Patient should avoid fruits, chocolate, beer, juices, teas, coffee, and antacids for 24 hours before and during collection. Use an acid-washed bottle for collection. Analyze via AAS or inductively coupled plasma/mass spectrometry (ICP/MS).

Testing of hair is not recommended.

Potential Health Effects:
Central Nervous System –
- **Not proven** as causative agent for Alzheimer's disease
- Encephalopathy (stuttering, gait disturbance, myoclonic jerks, seizures, abnormal EEG)

Bone –
- Osteomalacia (painful spontaneous fractures, hypercalcemia, tumorous calcinosis)

Lung –
- Pulmonary effects (cough, wheeze, etc.)

Suggested Treatments:
Asymptomatic patients with aluminum levels greater than the reference range–
- Evaluate potential exposures
- Retest over time

Patients with aluminum levels near or greater than 10 times the maximum reference value –
- Evaluate potential exposures
- Consider chelation with desferrioxamine (Amer. Acad. Ped. 1996)

Aluminum Content of Various Foods and Food Products

Beverages	Al conc. (ug/g)		Fruits	Al conc. (ug/g)		Herbs/Spices	Al conc. (ug/g)
Beer	0.07		Apple	0.1		Basil	3,082
Coffee (brewed)	0.235 - 1.163		Banana	0.05		Celery seed	465
Coffee (instant)	0.02 - 0.581		Peach	0.4		Cinnamon	82
Fruit juices	0.043 - 4.130		Raisins	3.1		Oregano	600
Liquor	0.148 - 0.635		Strawberries	2.2		Pepper (black)	143
Milk (all forms)	0.06 - 1.409					Thyme	750
Orange juice (concentrate)	0.06						
Soda	0.1 - 2.084						
Tea (black)	0.424 - 4.3						
Tea (herbal)	0.14 - 1.065						
Animal Products	**Al conc. (ug/g)**		**Grains**	**Al conc. (ug/g)**		**Vegetables/Legumes**	**Al conc. (ug/g)**
Beef, cooked	0.2		Biscuits (refrig. Dough)	16.3		Asparagus	4.4
Cheese (brick)	3.83 - 14.10		Bread, pumpernickel	13.2		Beans, green, cooked	3.4
Cheese (processed)	297		Bread, white	0.351 - 3.0		Beans, navy, boiled	2.1
Chicken, cooked (w/skin)	0.7		Bread, whole wheat	5.4		Cabbage, raw	0.1
Cottage cheese	0.2		Cold cereal	0.040 - 29.33		Cauliflower, cooked	0.2
Eggs	0.1 - 2.865		Corn chips	1.2		Corn	0.1
Fish	0.127 - 5.44		Cornbread	400		Cucumber, pared	0.1
Ham	1.2		Muffin, blueberry	128		Lettuce	0.6 - 7.16
Salami	1.1		Oatmeal, cooked	0.7		Peanut butter	5.8 - 6.29
Yogurt, plain low-fat	1.1		Oats	2.21 - 4.18		Peas	1.64 - 1.9
			Rice	1.7 - 1.97		Potato, red	3.63
			Spaghetti, cooked	0.4		Potato, sweet	1.01
						Potatoes, unpeeled, baked	2.4
						Potatoes, unpeeled, boiled	0.1
						Spinach, cooked	25.2
						Tomatoes, cooked	0.1
Other Food Products	**Al conc. (ug/g)**		**Other Food Products**	**Al conc. (ug/g)**			
Baking powder	2,300		Oreo cookie	12.7			
Candy, milk chocolate	6.8		Pickles	0.126 - 39.2			
Cocoa	45		Soup	0.032 - 3.6			
Creamer, powdered	25.7 - 139						

Condensed from ATSDR Toxicological Profile for Aluminum (1999), Table 5-4

Aluminum-containing Non-prescription Drugs

Antacids (e.g., Gaviscon, Maalox, Mylanta, Riopan, Rolaids)	
Aluminum salt used	**Al content/dose (mg)**
Aluminum hydroxide	35 - 208
Dihydroxyaluminum acetate	45 - 72
Aluminum carbonate	(not available)
Aluminum oxide	41
Bismuth aluminate	55
Magaldrate	51 - 61
Dihydroxyaluminum aminoacetate	100
Dihydroxyaluminum sodium carbonate	63
Analgesics (e.g., Arthritis Pain Formula, Bufferin, Vanquish)	
Aluminum salt used	**Al content/dose (mg)**
Aluminum hydroxide	9 - 52
Aluminum glycinate	35,717
Antidiarrheals (e.g., Kaopectate)	
Aluminum salt used	**Al content/dose (mg)**
Kaolin	120 - 1,450
Aluminum magnesium silicate	36
Attapulgite	500 - 600
Anti-ulcerative (e.g., Carafate)	
Aluminum salt used	**Al content/dose (mg)**
Aluminum sucrose sulfate	207

Condensed from ATSDR Toxicological Profile for Aluminum (1999), Table 5-7