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AN INVESTIGATION OF MERCURY POISONING AND HOME CONTAMINATION:

A CASE STUDY IN SUCCESSFUL COLLABORATION

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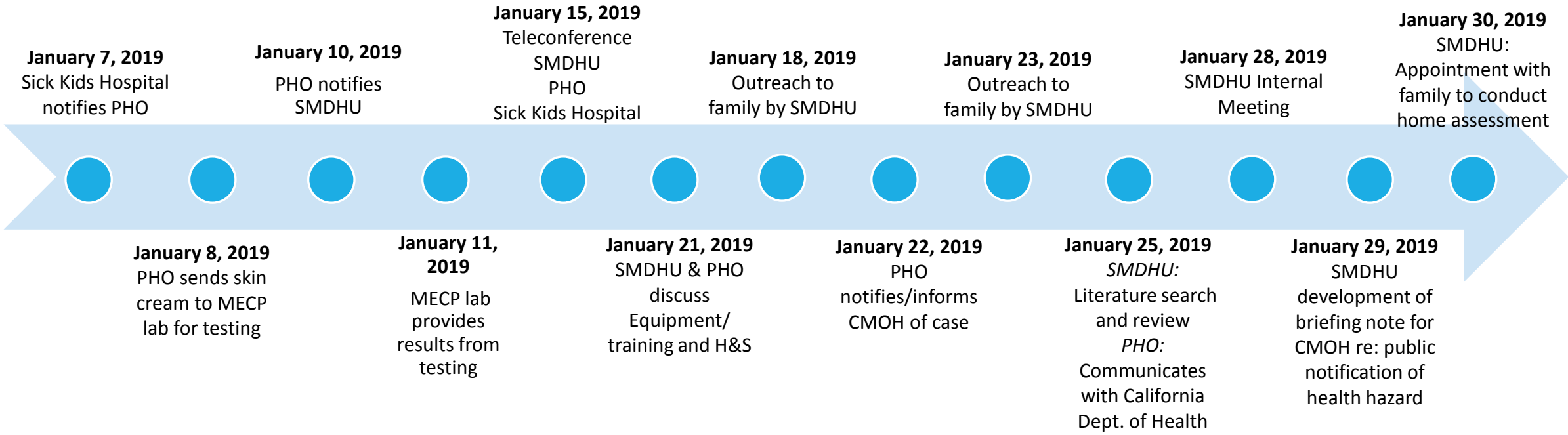
THIS PRESENTATION WILL…

- ✓ Describe how a local PHU in Ontario, with the support and expertise of PHO, investigated a case of mercury poisoning and subsequently assisted in the decontamination of a home following the use of a privately imported skin cream;
- ✓ Provide attendees information on how to conduct a home assessment following mercury contamination and how guidelines were developed in an absence of documented best practices;
- ✓ Provide an overview of the successes experienced while working collaboratively with provincial, federal and international public health stakeholders;
- ✓ Highlight the importance of notifying local health care providers and the general public of health hazards identified through public health investigations in order to assist with quick identification, diagnosis and treatment of heavy metal poisonings.

TIMELINE

Pre - Home Investigation: Notification and Response



CASE PRESENTATION:
SYMPTOMS AND HISTORY

- An infant presented to their doctor with gradual onset generalized symptoms, including weight loss, failure to meet developmental milestones, and irritability.
- An extensive clinical workup failed to uncover the cause and the patient was admitted for further workup and management.
- Mercury testing revealed grossly elevated urine and blood mercury levels.
- A more detailed history revealed that the mother was using a cream purchased through informal channels during a recent visit to Mexico.
- Although the cream was not labelled for use as a skin lightener, skin lightening creams are known to contain Calomel (mercurous chloride), a form of inorganic mercury, so suspicion arose…

CASE PRESENTATION:
CALOMEL

Calomel (AKA mercurous chloride):

- A form of inorganic mercury (the other two are elemental and organic)
- An uncommon source of mercury exposure (compared to organic AKA methylmercury, found in fish)
- Used in the past for a variety of medicinal/personal care products (laxatives, skin lightening creams, diuretics, antiseptics), and still found in unregulated markets or privately imported items

CASE PRESENTATION:

Possible Countries of Origin for Mercury Containing Skin-Lightening Products

- Use is particularly widespread in many African, Middle Eastern, Asian and Caribbean countries
- Manufactured in many countries and areas, including Bangladesh, China, Jamaica, Mexico, Pakistan, Philippines, Korea, Thailand, and the USA
- May be marketed as a “soap,” or “antiseptic soap;” product labels may note mercury or its forms
- Other mercury-containing cosmetics may include mascara, eye makeup, or eye makeup cleansers

World Health Organization. Mercury in skin lightening products. WHO. Geneva. Nov 2019. Available from: https://www.who.int/publications-detail/mercury-in-cosmetics-and-skin-lightening-products.

CASE PRESENTATION:
Access to Mercury Containing Skin-Lightening Products

- Mercury-containing products have been found in small shops that cater to specific ethnic communities, including in Canada
- Often privately imported, and available online
- These have included creams, gels, lotions and soaps

Gbetoh MH, Amyot M. Mercury, hydroquinone and clobetasol propionate in skin lightening products in West Africa and Canada. Environ Res. 2016 Oct;150:403-410.

CASE PRESENTATION:
SIGNS AND SYMPTOMS

Inorganic mercury poisoning:

- Inorganic mercury can be absorbed by inhalation or dermal contact; ingestion is minimal (unlike for methylmercury)
- Signs and symptoms of significant exposure include:
    - Neurotoxicity: Tremor, erythism (pathologic shyness), sensory peripheral neuropathy (numbness)
    - Vascular: Gingivostomatitis (inflammation of the gums), acrodynia (red, painful hands and feet), hypertension, tachycardia (elevated heart rate and blood pressure)
    - Nephrotoxicity: Reduced eGFR, renotubular dfxn (reduced kidney function)
    - If metallic and significant inhalation: Respiratory tract irritation (cough, shortness of breath)
    - If inorganic and significant ingestion: GI tract irritation (nausea, vomiting, pain)

CASE PRESENTATION:
TESTING

Inorganic mercury poisoning:

- Testing:
  - The biomarker of choice for inorganic (and elemental) mercury is a urine mercury level
  - The biomarker of choice for organic mercury is a blood mercury level
- N.B. Reference ranges are population averages (NOT levels of toxicity!) E.G.:
  - Blood mercury ULN is 18.4nmol/L; toxicity does not occur until 500-1000nmol/L
  - Urine mercury ULN is 3µg/L; toxicity does not occur until 20-100 µg/L

CASE PRESENTATION:
MANAGEMENT

- The infant was initially tested for blood mercury levels, and subsequently tested for urine mercury levels, and had grossly elevated levels in the urine, supporting a diagnosis of inorganic mercury poisoning.
- Additional family members were tested, but no significant elevations in mercury levels (including the mother) were observed. Lead levels were checked as well, and not elevated.
- The infant was chelated and improved clinically.

ENTER: PUBLIC HEALTH ONTARIO

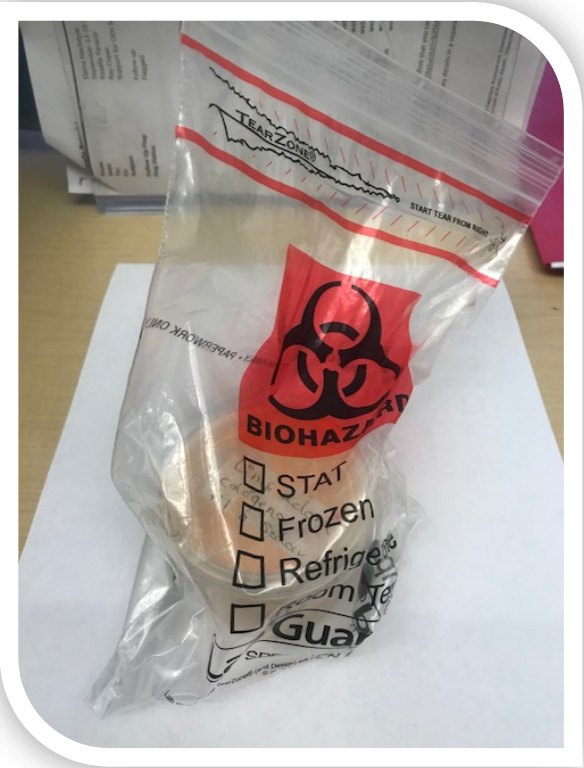


Image Source: PHO, 2019

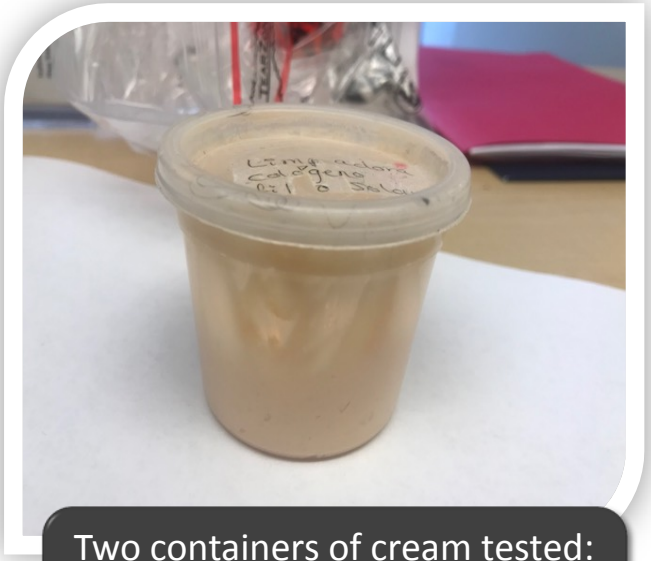
- PHO's Environmental and Occupational Health team was contacted by the physicians caring for the infant for guidance on next steps.
- PHO's role:
  - Identify, contact, and inform the appropriate public health unit (PHU)
  - Coordinate testing of the cream by the Ontario Ministry of Environment, Conservation and Parks Lab (MECP)
  - Provide loan of environmental testing equipment and instructions for use
  - Provide advice on conducting Hg assessment in residence with regards to safety for public health inspectors (PHIs), including selecting PPE
  - Assist in synthesis and interpretation of data
  - Provide technical advice for cleanup if necessary
  - Communicate with/alert relevant stakeholders

INITIAL CONSIDERATIONS

- After testing of the cream, a history taken by the PHI could help determine other possible sources of exposure:
  - Inorganic/Elemental mercury: Broken thermometers/ sphygmomanometers, fluorescent light bulbs, paints, fungicides, chemistry sets, pigments, solvents, traditional/herbal medicines
  - Organic mercury: Fish consumption
- In anticipating the home inspection, mechanisms of spread should also be considered:
  - Storage and handling of the product
  - Contamination of hard and soft surfaces
  - Clothes washer and dryer contamination
  - Vacuum cleaner and manual spread

SAMPLE TESTING

- Facilitated testing of cream obtained from the family
- Initial sample returned from the MECP lab, reported to contain 56,000ppm of mercury (5.6% inorganic Hg); second sample discovered during home visit (3.2% inorganic Hg)
- Maximum allowable under Canadian standards is 1ppm Hg
- Health Canada was alerted, who communicated with their counterparts in Mexico (country of origin) to alert the public



Two containers of cream tested:
Cream 1: 56000 ppm (5.6% Hg)
Cream 2: 32000 ppm (3.2% Hg)

Image Source: PHO, 2019

PHO'S ROLE:
OCC HEALTH AND SAFETY CONSIDERATIONS

Issues:

- Mercury is a Designated Substance by the Ontario Ministry of Labour
- Elemental (and to a lesser extent, inorganic) forms are volatile and produce a vapor which can be inhaled/absorbed
- Therefore it is the employer's responsibility to comply with the applicable regulation, which includes performing/documenting a risk assessment to determine if there is a risk of exposure, and if so, how to mitigate this risk

PHO'S ROLE:
OCC HEALTH AND SAFETY CONSIDERATIONS

Solutions:

- The EPA Mercury Response Guidebook delineates what kind of RPE could be used depending on known/anticipated ambient concentrations of mercury:

Breathing Zone Conc. (µg/m^3)	Level	Recommended RPE
<25	D	None
>25-500	C	Full-face with mercury cartridges
500-625	Modified C	PAPR
>625	B	SCBA

USEPA. National Elemental Mercury Response Guidebook. USEPA. Washington, DC. August 2018. Available from: https://goto.oahpp.ca/areas/environment/teamsite/Reference%20Documents/Mercury%20Response%20Guidebook_083118%20EPA.pdf

WORKPLACE EXPOSURE LIMITS/GUIDELINES FOR MERCURY

Breathing Zone Concentration ($\mu g/m^3$)	Action	Rationale
25	Ontario 8-hour time-weighted average occupational exposure limit. Respiratory PPE is required if sustained for the entire 8h workday.	Concentration at which urine levels of Hg exceed 50ug/g creatinine in workers, increasing the risk of tremors in workers from exposure at this level for >10 years [1]
75	Short-term exposure limit (STEL): Worker not to be exposed to this concentration for more than 15 minutes.	ACGIH general recommendation for substances without STEL. [2]
125	Ceiling exposure limit (C): Worker not to be exposed to this level for any duration. Evacuate immediately.	ACGIH general recommendation for substances without ceiling limit.[2]

Table 1: Action Concentrations for Inorganic Hg Vapour[1,2]

1. American Conference of Governmental Industrial Hygienists (ACGIH). Mercury, All forms except Alkyl. 2009 TLVs and BEIs Threshold limit values for chemical substances and physical agents & Biological exposure indices with 7th edition documentation. ACGIH. Cincinnati, OH. 2009. Available by subscription.
2. American Conference of Governmental Industrial Hygienists (ACGIH). 2018 TLVs and BEIs Based on the documentation of the threshold limit values for chemical substances and physical agents & biological exposure indices. ACGIH. Cincinnati, OH. 2018.

PHO'S ROLE:
OCC HEALTH AND SAFETY CONSIDERATIONS

Solutions:

- We consulted scientific literature which helped inform risk characterization; case reports and gray literature from other relevant agencies (USEPA, ATSDR, California DPH) suggested that exposure is expected to be low. Similar cases in the Southern US provided good baseline data.
  - The context of the case was reassuring: use of the cream was stopped months before, other family members were well and tested normal, and the source had been (presumably) removed
  - The investigation involved real-time measurements so action levels were communicated (e.g. levels of concern and when to evacuate)

PHO'S ROLE:
ENVIRONMENTAL INVESTIGATION

Issues:

- Assessing breathing zone levels of mercury in the home

Solutions:

- The Environmental and Occupational Health team at PHO has an instrument loan program where a variety of environmental monitoring instruments are available for loans to health units in Ontario.
- Provided a loan to the health unit of a Mercury Tracker IP3000 by Mercury Instruments which is a direct reading instrument that is able to measure airborne mercury levels ranging from 0.1-2000 $\mu g/m^3$
- Training on use of the instrument was provided to the PHI conducting the mercury assessment as well as follow-up technical support and sampling strategy guidance.

PHO'S ROLE:
ENVIRONMENTAL INVESTIGATION

Issues:

- Assessing contaminated items and surfaces which could increase breathing zone levels and also be a source for dermal Hg exposure

Solutions:

- PHO consulted the scientific and gray literature from other relevant agencies (New York DH, Illinois DH, ATSDR, California DH).
- Illinois DH and ATSDR provided guidance on bagging small to medium sized items and heating to room temperature to determine contamination level.
- Mercury levels from previous surveys were reported in published literature for breathing zone, appliances and some personal items as well as areas likely to be contaminated.
- The PHI was advised to consider living spaces, laundry room, appliances, as well as areas within the home where the cream was applied and stored (potentially highest) as well as additional locations identified from the history taken.

PHO'S ROLE:
ENVIRONMENTAL INVESTIGATION

Issues:

- Interpreting results as there are no Ontario specific guidelines for mercury levels in residences

Solutions:

- Ongoing phone consultations with California DH - experience with residential Hg assessments
- Illinois DH, California DH and ATSDR provide action levels for safe occupancy, determining whether items are contaminated.

GENERAL PUBLIC EXPOSURE GUIDELINES

Breathing Zone Concentration ($\mu g/m^3$)	Action	Rationale
<1	None. Levels are safe for inhabitants and remediation not necessary.	This is 26 times lower than concentrations referenced in health guidance values.[1]
>10	Evacuation of residents from that area/room until cleanup is performed.	Lowest concentration at which urine levels of Hg increase.[1]
≤0.2	Targeted goal level for reduction of mercury set by California DH for cases involving skin cream	This is ATSDR minimum risk level for exposure more than 365 days, unlikely to cause measurable risk for adverse, noncancerous health effects. Dual air and dermal exposure pathways, young children in contaminated homes and differences in vaporization of mercury from calomel and elemental mercury.[2]

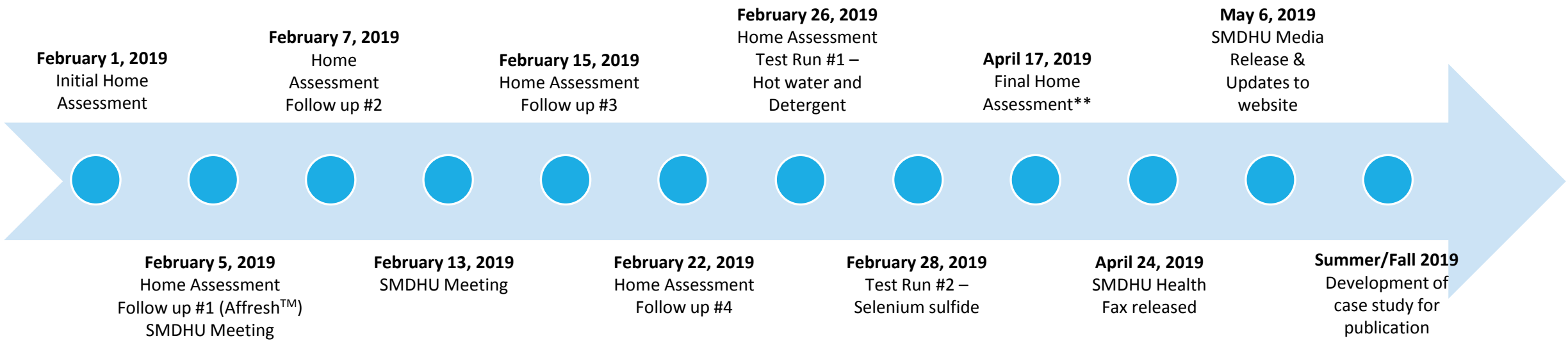
1. Agency for Toxic Substances and Disease Registry (ATSDR). Chemical-specific health consultation for joint EPA/ATSDR national mercury cleanup policy workgroup; Action levels for elemental mercury spills. ATSDR. Atlanta. March 22, 2012. Available from: https://www.atsdr.cdc.gov/emergency_response/action_levels_for_elemental_mercury_spills_2012.pdf.
2. Copan L, Fowles J, Barreau T, McGee N. Mercury toxicity and contamination of households from the use of skin creams adulterated with mercurous chloride (Calomel). International journal of environmental research and public health. 2015 Sep;12(9):10943-54.

ACTION LEVELS FOR CONTAMINATED ITEMS:
CONSIDERATIONS FOR PHI ON-SITE

- No Ontario specific guidelines for mercury contaminated items or safe breathing zone levels for general public.
- ATSDR: 3-6µg/m^3 for personal items to remain in the home based on target breathing zone levels at <1µg/m^3 based on bagging method for small items.
- Illinois DH and California DH: <1µg/m^3 for allowing personal items to remain in the home.
- California DH level was set to target breathing zone levels of 0.2µg/m^3.

TIMELINE

Investigation and Follow Up: Local Public Health Unit and PHO Response



** *Gap between February 28 – April 17th – Equipment was redeployed to another health unit to assist with a similar investigation*

LOCAL PUBLIC HEALTH RESPONSE:
ENVIRONMENTAL INVESTIGATION

Issues:

- "New" investigation (no guidance or best practice documents available)
- Sensitivity of the situation (trust, fear, nervousness, anxiety)

Solutions:

- Occupational health and safety considerations, training and awareness of risks
- Development of procedures and documents through ongoing consultation with PHO
  - *PPE for Home Investigation of Mercury Exposure (PHO)*
  - *Tips on Conducting a Residential Mercury Assessment (PHO)*
  - *Your Home Environmental Assessment – What to Expect (SMDHU)*
  - *Washing Machine Decontamination*

LOCAL PUBLIC HEALTH ROLE:
ENVIRONMENTAL INVESTIGATION

Health Hazard Prevention and Response Management

Risk Mitigation and Reduction

Education and Awareness

- Case history (exposure assessment)
- Investigation of cream source
- IAQ risk assessment and Hg vapour monitoring throughout the home
  - Evaluation of personal belongings and living space
- Onsite education, risk mitigation and reduction
- Continued consultation with PHO once sampling results obtained

INITIAL ASSESSMENT:
RESULTS & INTERVENTIONS

Assessment Areas

- Bedrooms
- Bathrooms
- Kitchen
- Laundry Room
- Open living spaces
- Appliances
- Family's vehicle
- Personal belongings
  - *Make up bags, pillow*

Result Range

0.0 µg/m³ – 2.9 µg/m³

Note: Make up bags (2.6 µg/m³ and 2.9 µg/m³), Pillow 1.5 µg/m³

Image Source: PHO, 2019

Interventions

- Disposal of personal belongings
- Limit access to laundry room
- Washing machine decontamination recommendations
- Belongings bagged to allow for potential off-gassing and for re-testing
- NO USE OF WASHING MACHINE

FOLLOW UP ASSESSMENT: Affresh™
RESULTS & INTERVENTIONS

Assessment Areas

- Bagged items from initial assessment
- Laundry room
  - Three breathing zone levels monitored:
    - *Adult, toddler, infant*
- Washing Machine
  - *Door handle*
  - *Middle of drum*
  - *Back/Sides of drum*

Results

Bagged Items:
0.7 µg/m³ – 1.5 µg/m³

Breathing Zones:
0.0 µg/m³ – 0.3 µg/m³

Washing Machine:
Initial Sample 25.9 µg/m³
Resample 15.8 µg/m³

Interventions

- Disposal of belongings
- Limit laundry room access
- Consultation with PHO
- Recommendations:
  - *4-5 hot water cycles*
  - *4-5 hot water & detergent cycles*
- Additional site visits (x3)
- NO USE OF WASHING MACHINE

FOLLOW UP ASSESSMENTS: Hot Water & Detergent
RESULTS & INTERVENTIONS

Assessment Areas

- Bedroom Closets*
- Children's clothing*
- Washing Machine

Image source: Pixabay

Results

Closets and Clothing:

0.2 µg/m³ - 0.8 µg/m³

Breathing Zones:

0.0 µg/m³ – 0.3 µg/m³

Washing Machine:
Initial Samples
20.1 µg/m³ & 2.6 µg/m³
Resamples
5.4 µg/m³ & 1.9 µg/m³

Interventions

- Further washing machine decontamination needed
- Consultation with PHO re: next steps
  - Selenium sulfide
  - What levels are "safe" and "acceptable?"
  - Test Runs
- NO USE OF WASHING MACHINE

DECONTAMINATION GUIDANCE

- California DH recommended cleaning hard surfaces with powdered sulfur as this combines with mercury and conducting several wash cycles with sulfur combined with water or a dandruff shampoo containing selenium sulfide in washing machine to decontaminate.
- PHO via California DH suggested several wash cycles in washing machine with extra strength Selsun Blue™
  - Detergent in shampoo would be more effective at removing cream residue in the drum, while the active ingredient of selenium sulfide binds to mercury

Image Source: Pixabay

TEST RUN 1: Detergent
RESULTS & INTERVENTIONS

Assessment Areas

- Washing Machine
- Dirty towels and rags, old clothes

Considerations

- Ambient air levels
- Bagged items
- Dryer
- Pre & Post Measurements

Results

Bagged Items: 2.1 µg/m^3
Ambient Air*: 0.0 µg/m^3 – 1.9 µg/m^3
Washed Items: 1.0 µg/m^3
Dried Items: 0.7 µg/m^3

Washing Machine:
Pre: 2.6 µg/m^3
Post: 3.7 µg/m^3

Interventions

- Follow up testing: Bagged & air dried items
- PHO consultation
  - Use of selenium sulfide product
  - Run 20 cycles with product

TEST RUN 2: Selsun Blue™
RESULTS & INTERVENTIONS

Assessment Areas

- Washing Machine
- Bagged items (air dry and dryer dried)

Considerations

- Evaluation of Selenium product
- Ambient air
- Bagged items
- Pre & Post

Results

Bagged Items: 1.7 µg/m³
Ambient Air*: 0.1 µg/m³
Washed Items: 0.6 µg/m³
Dried Items: 0.3 µg/m³

Washing Machine:
Pre: 0.9 µg/m³
Post: 0.5 µg/m³

Interventions

- Recommendation to run an additional 20 cycles with Selsun Blue™
- Resume use of washing machine

FINAL ASSESSMENT:
RESULTS & INTERVENTIONS

Assessment

Washing Machine

Ambient air levels

Result Range

Breathing Levels: 0.0 µg/m

Washing Machine:
0.1 µg/m³ – 0.2 µg/m³

Successful decontamination of washing machine!!!

Considerations

Continued effectiveness of selenium sulfide product

Interventions

- Education provided and full use of washing machine recommended

PUBLIC HEALTH RESPONSE:
EDUCATION & AWARENESS

- Internal & External
  - Literature search
  - Literature review
- Communication of risk to the public, health care providers
  - Briefing note to CMOH
  - Development of additional web information
  - SMDHU Health Fax and Media Releases

AFTER THE INVESTIGATION…
DEBRIEF AND LESSONS LEARNED

- Interaction and continued follow up with the family
- Importance of contacting Mexican authorities, understanding political sensitivity
- Investigations of this nature expands knowledge outside traditional routes of Hg exposure (e.g. consumption of fish)
- Opportunity for advocacy…
  - *Primary care and public health working together (identified health hazards and coordinated response)*
  - *Reporting of heavy metal poisoning to public health*
  - *Benefits vs. risks of reportability through traditional public health channels*

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